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PROGRESS REPORT



of the  
**MARKET QUALITY RESEARCH DIVISION**  
**MARKETING AND NUTRITION RESEARCH**

JULY 1, 1970

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Agricultural Research Service  
UNITED STATES DEPARTMENT OF AGRICULTURE



This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation.

The summaries of progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1969, and June 30, 1970. Current agricultural research findings are also published in the monthly USDA publication Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, United States Department of Agriculture, Hyattsville, Maryland.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife -- if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the United States Department of Agriculture or an endorsement by the Department over other products not mentioned.



Issued December 1970

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PROGRESS REPORT  
OF THE  
MARKET QUALITY RESEARCH DIVISION  
MARKETING AND NUTRITION RESEARCH  
AGRICULTURAL RESEARCH SERVICE

INTRODUCTION

The research of the Market Quality Research Division is concerned with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport, and distribution of agricultural commodities, and the development of new methods and devices for measuring and characterizing quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at Beltsville, Maryland, which includes the Instrumentation Research Laboratory, Color Research Laboratory, Postharvest Physiology Pioneering Research Laboratory, and personnel of the Field Crops and Animal Products Research Branch and the Horticultural Crops Research Branch. There are 26 field stations located throughout the country; 13 are located at state universities or branch experiment stations and 2 are in terminal markets. A new field station is the European Market Quality Research Laboratory at Rotterdam, The Netherlands.

Although a large variety of excellent quality fresh and processed agricultural products are retailed at reasonable prices throughout the year, there is need for further research on methods to reduce spoilage and waste during storage, transportation, and distribution, and to improve methods to reduce spoilage and waste during storage, transportation, and distribution, and to improve methods for evaluating quality. Stored product insects and market diseases still destroy large amounts of produce regardless of costly controls. There is urgent need for new methods of control that will not create health or environmental hazards due to pesticide residues. Automated objective methods of quality evaluation are increasingly needed to make possible rapid reliable grading and inspection of large quantities of produce under modern packing, handling, and transporting conditions.

An appreciable amount of the Division's research is related to the effective performance of the service divisions of the Consumer and Marketing Service and the regulatory and control divisions of the Agricultural Research Service responsible for standardization, inspection, and grading of agricultural commodities, and for preventing entry of foreign pests into the United States and spread of domestic pests from quarantined areas. The Division also works closely with industry and other Government agencies on various problems relating to agricultural commodities in the marketing channels, including export to the valuable European markets.

## EXAMPLES OF PROGRESS

Subsampling Mill for Peanut Kernels.--Individual peanut kernels may contain 1,000  $\mu\text{g}$  aflatoxin per gram. Since a 10,000 kernel sample of peanuts with only one such highly contaminated kernel contains an average of 100  $\mu\text{g}$  aflatoxin per kg of peanuts, the problem of obtaining a representative subsample for aflatoxin analyses is therefore extremely difficult. A simple, compact mill was developed to simultaneously comminute and subsample peanut kernels at the rate of 3 kg (6.6 pounds) per minute. Comminution of peanut kernels was finer than with equipment presently used in many laboratories. Very little oil was expressed from the comminuted material which was easily blended and subdivided. Tests with samples containing known amounts of aflatoxin contaminated kernels indicated subsampling accuracy. Use of the mill is proposed for comminuting and subsampling a wide variety of granular materials for aflatoxin or other analyses.

New Sweetpotato Storages.--Market quality research conducted in cooperation with North Carolina Agricultural Experiment Station has resulted in an entirely new concept in handling, curing, and storing sweetpotatoes. Storages have recently been built in Maryland, North Carolina, South Carolina, Texas, and Virginia with a combined capacity of over one million boxes (bushels). These new storages feature separate rooms with controlled temperatures and humidity for curing roots. The roots are handled in pallet boxes, a system which is more gentle and reduces root damage. The storage area has trench heating and humidification and overhead ventilation for more uniform storage conditions. The new handling and storage system improves the quality of sweetpotatoes and increases the value of the product. The increased value is estimated at \$750,000 annually. Labor savings have been estimated by operators to be \$250,000 annually.

Lettuce Problem Solved.--During the 1969-70 shipping season, a serious disorder called "Brown Stain" affected 2900 carlots of California lettuce. This lot of lettuce valued at \$5.5 million had seriously reduced market quality, salability, and consumer acceptance. Laboratory and shipping tests showed that the disorder was caused by  $\text{CO}_2$  levels above 2% during transit. Further studies showed that the disorder could be eliminated by aeration or otherwise ridding the loads of  $\text{CO}_2$  during the transit period.

New Fungicide Provides Better Control of Postharvest Decay.--Laboratory, packinghouse, and export shipping tests showed that thiabendazole gave more effective decay control of Hamlin, Pineapple, and Valencia oranges than the standard commercial treatment. Flood and dip applications of the fungicide, which is approved by FDA, lengthened the possible storage period, extended the shelf life, and improved the export quality of citrus.



Determination of Stinkbug Damage in Soybeans.--The rapid increase in the production of soybeans in the southern states has intensified the problem of stinkbug damage. Soybeans with stinkbug punctures have lower oil content and higher fat acidity than sound beans. The percent of small beans and the number of discolored and moldy beans developing during storage are greatly increased. Buyers discount prices paid for stinkbug damaged soybeans on the basis of percent of damage. It became increasingly necessary to have a method for determining extent of damage that is accurate and reasonably rapid. The decrease in soybean density resulting from stinkbug punctures forms the basis for the new method. An instrument has been developed which measures the time required for individual seeds to fall from one fixed point to another through a vertical column of water. The difference between the mean time of fall of a smaller number of undamaged seeds picked from a sample and the mean time for the sample as a whole is a measure of the relative amount of stinkbug damage in the sample.

Rapid Determination of Salmonellae.--Salmonellosis is an important food-borne infectious disease in the United States. The present standard test of foods takes up to 4 days, and requires trained technicians and much equipment and glassware. A new test was devised, using a special glassware apparatus, in which characteristic motility and biochemical reactions of these bacteria can be determined within 48 hours. The apparatus consists of a central chamber with three U-shaped sidearm tubes projecting from its sides. The sample to be tested is placed in broth in the central chamber. Motile bacteria (such as salmonellae) will then grow through semi-solid agar seals in the sidearms. If salmonellae are present, chemicals incorporated in the agar seals change color in characteristic ways. Motile bacteria reacting positive biochemically for Salmonella are then verified by a rapid and simple agglutination test. Plant laboratory personnel easily perform these procedures. A very inexpensive version of this test using a "Mason" jar plus U-shaped test tubes was also devised; it is effective, but slightly more difficult to use.

Dichlorvos Resin Strips Utilized to Protect Stored Grains.--A single dichlorvos resin strip per 1000 cubic feet of headspace in a storage bin was found to protect shelled corn, wheat, and soybeans from Indian-meal moths for approximately 3 months. Concentrations in the air in the overspace were far below the threshold level for the safety of personnel working in the bin and residues on the commodity were extremely low on the surface and entirely absent 6 inches or more below the surface. Indian-meal moths are new pests of stored soybeans and no control measures are presently approved. Therefore this method provides a means of protecting over 700 million bushels valued at over \$1.7 billion. Of special significance too is the value of this treatment in protecting Government held stocks, not only of soybeans but of corn and grain sorghum as well. This represents more than 160 million bushels, valued at almost \$200 million. The treatment is inexpensive and available at a time when the moth has become sufficiently resistant to malathion in some areas to make applications within permitted residue limits impractical.

Biological Agent Developed for Major Stored Product Pest.--A microbial insect control agent containing  $1 \times 10^9$  capsules per gram of a granulosis virus of the Indian-meal moth has been formulated as a wettable powder. The use of biological agents as a desirable alternative to chemicals is often cited in Congress. However, actual commercial use is prevented by a lack of a protocol in FDA for clearance and limited industrial interest in developing biological agents with narrow spectrum use. Initial research on production of the virus was done by USDA and the formulation developed in cooperation with industry. Populations of the moth are not eliminated immediately, but subsequent generations are infected and destroyed and new populations are incapable of establishment in the "exposed" commodity. Granulosis viruses generally have a high degree of host specificity and are therefore incapable of attacking beneficial insects or higher animals. Estimated damage by this insect if uncontrolled exceeds \$100 million per year. Although cost of treatment with this biological agent would be no less than that of chemical pesticides, it would serve as an alternative to them, whether needed because of prohibitive action or the development of resistant strains of insects.

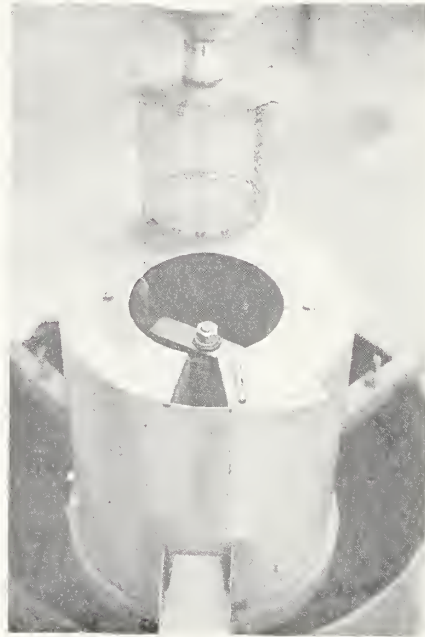
Changes in Carotenoid and Oil Content During Maturation of Peanut Seeds.--The loss of peanut oil color with maturity of the seeds is well documented. Recent work has given understanding to the changes in the color of peanut oil during maturation of the seeds. Data, presented as percent oil, indicate that the oil fraction increased rapidly in relation to other constituents during the 4th to 7th week from pegging but at subsequent harvest dates, this increase was not as great. Comparison of the increase in oil with the very slight increase in carotenoid content shows that the reduction in carotenoid concentration of extracted or pressed oil is due to a dilution effect by the oil. This explains the cause for the change (loss) in oil color which occurs in the oil during maturation of the seed.

Lighting Conditions for Evaluation of Beef Marbling and Color.--A meat grader evaluates animal carcasses for color, fat-to-lean ratio, and marbling to designate a quality grade. Yet, little information was available on how lighting may influence subjective evaluation of meat quality. Recent studies showed that both intensity and type of light significantly affect the evaluation of meat color. Color scores obtained under incandescent types of light were significantly lower than the scores obtained under fluorescent types of light. For example, a beef carcass could be scored as darker under "cool white" fluorescent light than under incandescent light. This difference in the evaluation of color might, in some cases, influence the maturity score of the beef carcass.

Determination of Aflatoxin in Cottonseed.--A standard method of analysis for determination of aflatoxin in seed products has not been adopted because of the great variety of interfering pigments and fluorescent compounds present in seeds. In cottonseed products the pigment gossypol causes the major interference in detection of aflatoxin. A procedure was developed for removing interfering gossypol pigments with ferric hydroxide gel. The need for purification of the aflatoxin fraction through silica gel columns is eliminated thereby reducing the time and cost of analysis. In addition, since greater amounts of aflatoxin B<sub>1</sub> are recovered by the new method it appears to be more accurate.

Estimation of Aflatoxin in Corn by "Dockage" Assay.--A method of analyzing corn for aflatoxin was developed by assaying only the broken corn, foreign material, and chaff (dockage). Results indicate that dockage contains most of the aflatoxins. Therefore the dockage provides a magnified view of the aflatoxin contamination, thereby improving the sensitivity of detection. Using this technique, it is possible to make a representative analysis on a given shipment of corn (i.e., truck, boxcar, vessel, etc.). A practical benefit of these findings is that removal of dockage by sieving might reduce the aflatoxin content of commercial corn to insignificant levels which could not be detected by the methods of analysis.

# SUBSAMPLING PEANUT MILL FOR AFLATOXIN TESTS DEVELOPED



## SITUATION:

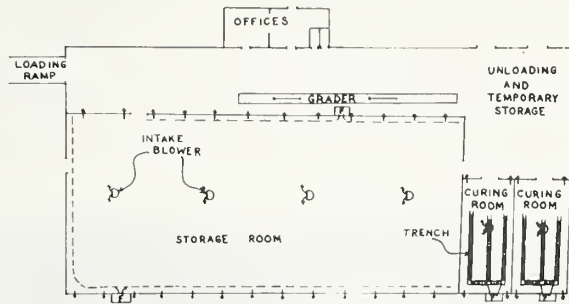
- ▷ MOST AFLATOXIN IN ONE OR FEW KERNELS
- ▷ AFLATOXIN CONTENT HIGH IN SOME KERNELS
- ▷ EXPRESSED OIL HINDERS BLENDING

## ADVANTAGES:.

- ✓ LARGE SAMPLE USED
- ✓ COMMINUTES PEANUTS
- ✓ LITTLE OIL EXPRESSED
- ✓ YIELDS REPRESENTATIVE SAMPLE
- ✓ DOES JOB IN ONE MINUTE
- ✓ USED IN INSPECTION LABORATORIES



# MARKET QUALITY RESEARCH LEADS TO DEVELOPMENT OF NEW TYPE SWEETPOTATO STORAGES



- FEATURES :**
- ✓ TRENCH HEATING AND HUMIDIFICATION
  - ✓ SPECIAL CURING ROOMS
  - ✓ PALLETIZED HANDLING
  - ✓ OVERHEAD VENTILATION

**RESULTS :** ► **IMPROVED QUALITY** FROM BETTER CURING AND  
MORE GENTLE HANDLING  
► **LABOR SAVING** 250,000 DOLLARS ANNUALLY  
► **PRODUCE VALUE INCREASED**  
750,000 DOLLARS ANNUALLY

**NEW STORAGES BUILT IN —** MARYLAND — NORTH CAROLINA —  
SOUTH CAROLINA — TEXAS — VIRGINIA

WITH COMBINED CAPACITY OF OVER 1 MILLION BUSHELS

# LETTUCE PROBLEM SOLVED

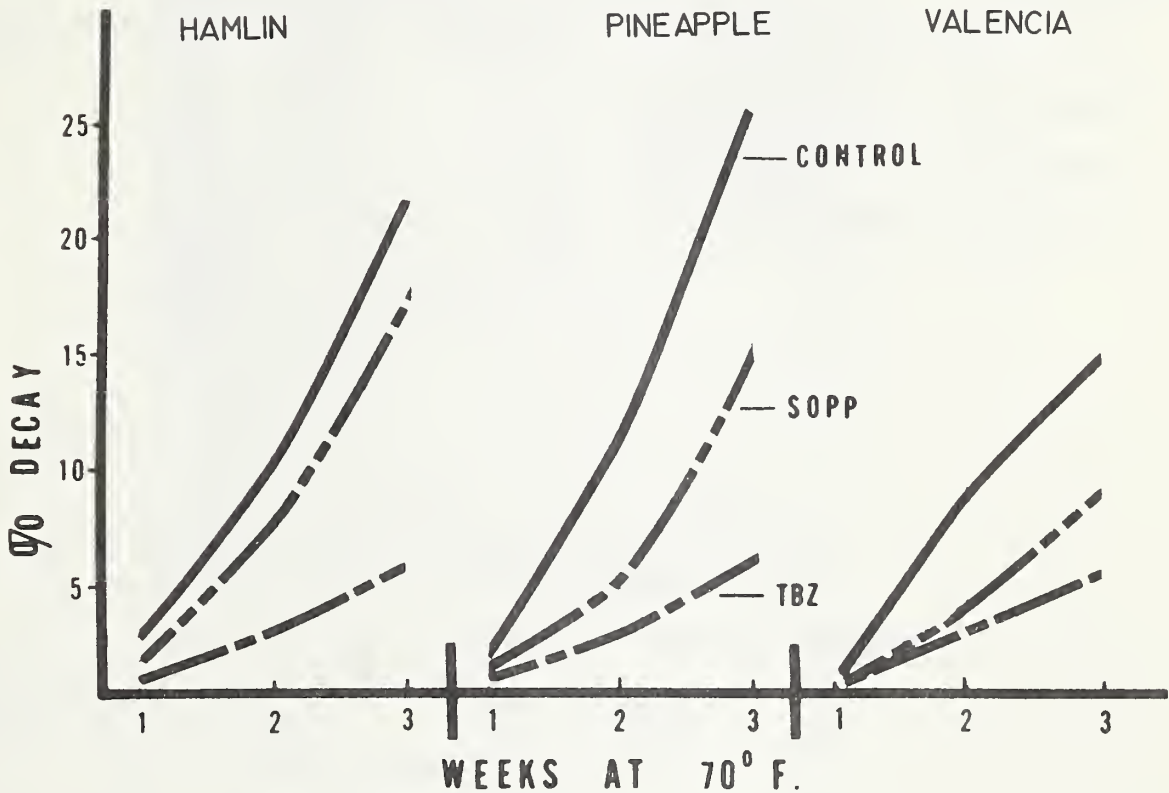
— GREAT BENEFIT TO LETTUCE INDUSTRY



- ▷ THREAT TO 136 MILLION DOLLARS CALIFORNIA LETTUCE INDUSTRY
- ▷ 2900 CARLOTS WORTH 5.5 MILLION DOLLARS AFFECTED IN 1969 — 70
- ▷ CAUSED IDENTIFIED AS EXCESS CO<sub>2</sub> IN TRANSIT
- ▷ CONTROL DEVELOPED WHICH ELIMINATES PROBLEM



# NEW FUNGICIDE PROVIDES IMPROVED CITRUS DECAY CONTROL



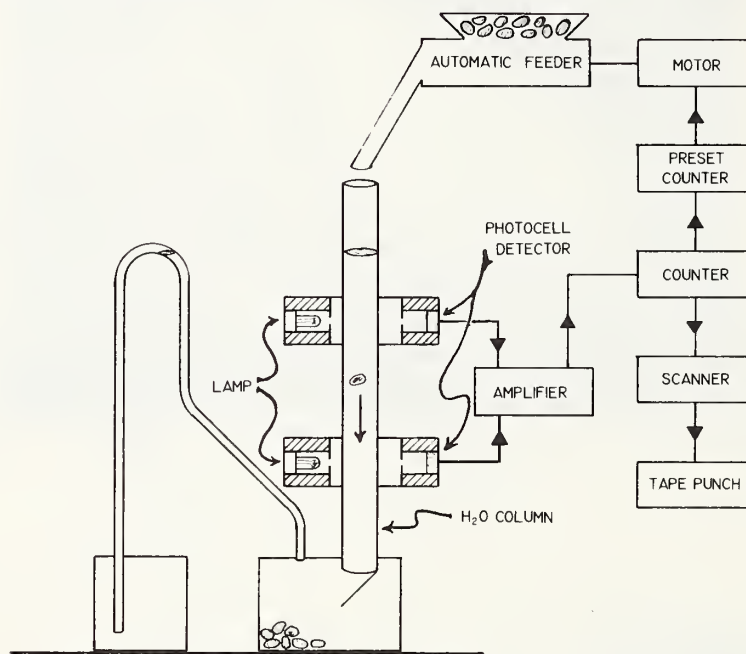
## ADVANTAGES:

- ▷ EXTENDS SHELF LIFE
- ▷ IMPROVES EXPORT QUALITY
- ▷ APPROVED BY FDA
- ▷ LENGTHENS STORAGE PERIOD
- ▷ EFFECTIVE FOR ALL CITRUS

# METHOD FOR DETERMINING STINKBUG DAMAGE OF SOYBEANS

## PROBLEM:

- ▷ STINKBUG DAMAGED BEANS -- PRODUCE LESS OIL; MORE FATTY ACIDS
- ▷ SUBJECT TO MOLD DAMAGE
- ▷ DIFFICULT TO DETECT
- ▷ REDUCES PRICE OF BEANS



## PROCEDURE:

- ▷ BEANS DROPPED INTO COLUMN OF WATER
- ▷ RATE OF FALL MEASURED

RESULTS PRINTED OUT

## ADVANTAGES:

RAPID OBJECTIVE SEPARATION  
SEMI-AUTOMATED EQUIPMENT

# NEW RAPID TEST FOR SALMONELLA DEVELOPED



LEFT, BANWART FLASK; RIGHT, MASON JAR VERSION

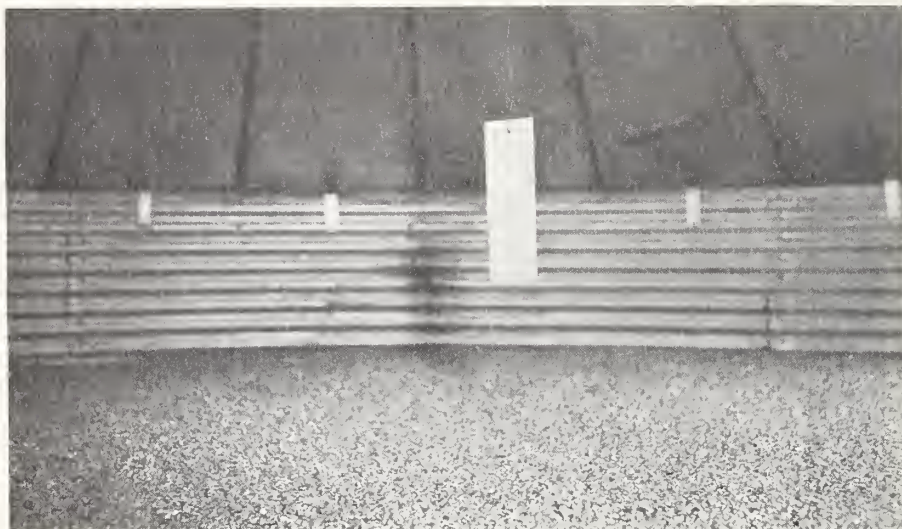
## SITUATION:

- ▷ TEST REQUIRES 4 DAYS
- ▷ MUCH EQUIPMENT NEEDED
- ▷ PROCEDURE COMPLICATED
- ▷ TECHNICIANS NEED TRAINING

## ADVANTAGES:

- TEST COMPLETED IN 48 HOURS
- MINIMUM PIECES OF EQUIPMENT
- PERSONNEL REQUIRES MINIMUM TRAINING
- MASON JAR VERSION IS INEXPENSIVE

## DICHLORVOS RESIN STRIP



is the most effective and economical method found to protect soybeans, corn, and grain sorghum in commercial and government storage against malathion—resistant Indian—meal moth.

Value of crop protected: 700 million bushels of soybeans in commercial storage — \$1.7 billion; 160 million bushels of soybeans, corn, and grain sorghum in government storage — \$200 million.

ONE DICHLORVOS STRIP PER 1000 CU. FT. HEADSPACE GIVES 3 MONTHS PROTECTION



CORN PROTECTED BY STRIP



CORN UNPROTECTED BY STRIP



# BIOLOGICAL CONTROL OF MAJOR PEST OF STORED PRODUCTS

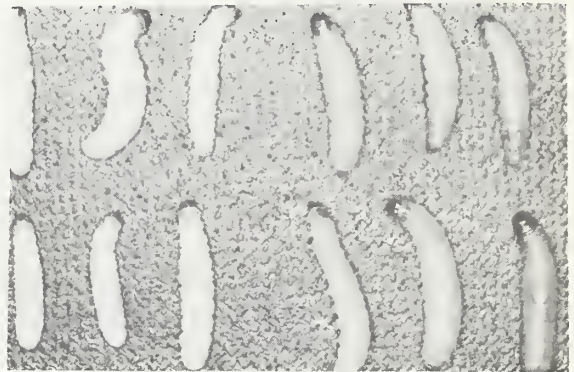
## SINGLE TREATMENT STOPS INDIAN-MEAL MOTH BEFORE 2ND GENERATION

INFECTED MOTHS TRANSMIT DISEASE

TO LARVAE WHICH ARE KILLED.



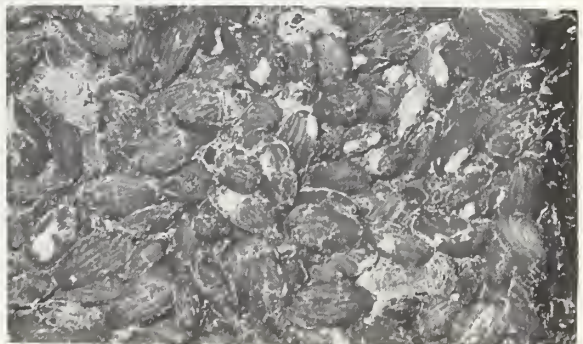
A, Infected ; B, Uninfected .



ALMONDS TREATED



ALMONDS UNTREATED



## CITRUS AND SUBTROPICAL FRUITS

## Quality Maintenance in Storage

Controlled atmosphere storage.--Continued research has shown that the usefulness of low oxygen or high carbon dioxide levels in storage atmospheres is limited for decay control of California citrus fruit. Off-flavors and rind injuries develop in atmospheres which inhibit or retard decay development or fungus sporulation.

Grapefruit.--When grapefruit was stored at 40° F., a temperature at which pitting is induced, ethylene tended to decrease the amount of pitting, the secondary rots which follow pitting injury, as well as total decay.

After 3 months' storage at 50° F. in ethylene (0-200 ppm), Florida grapefruit picked in February had 5% decay; after 2 and 3 months' storage fruit picked in March had 16% and 17% decay, respectively; and after 1 and 2 months' storage, fruit picked in April had 23% and 40% decay, respectively. At 50° to 60° F., the temperature range where pitting is not a factor, ethylene tended to increase stem-end rot of Marsh grapefruit. In general, more storage decay was found to occur at the higher ethylene concentrations.

Lemons.--Arizona lemons stored 9 months at 57° F. with relative humidities approaching saturation were in marketable condition with a weight loss of less than 2%. Waxed fruit treated with 2,4-D had less than 1% loss from decay. Bronzing was found to be a fairly serious defect but could be controlled with gibberellic acid. Lemons stored in a controlled atmosphere containing 10.5% oxygen retained the most green color and showed the least bronzing.

Avocados.--Controlled atmosphere storage looks promising as a method of extending the marketing period of avocados. All Lula avocados stored in a controlled atmosphere of 2% oxygen, 10% carbon dioxide, and 88% nitrogen at 45° F. were in acceptable condition after storage for 20 or 40 days, and 55% were acceptable after 60 days. All fruit stored in air were completely decayed after 40 or 60 days in storage at 45° or 50°. Controlled atmosphere storage was found to be more effective than air storage for all tested storage periods. A temperature of 45° was generally as good or slightly better than 50° for use in controlled atmosphere storage. Decay, external darkening, and percentage weight loss were significantly lower in the fruit held in an atmosphere of 2% oxygen, plus 10% carbon dioxide than in air. Although the removal of ethylene from the controlled atmosphere chambers resulted in a delay of 1 to 2 days in the time required for the avocado fruit to soften at 70°, more acceptable fruit was observed in these scrubbed chambers.



Common storage.--The storage of Robinson tangerines, Nova tangelos, and Page and Lee hybrids for 2 weeks at 34°, 40° and 45° F. followed by a 1- to 2-week holding period at 70° F., resulted in little or no difference in decay development. However, in all cases, the brightest peel color was attained at 45° F. Negligible decay resulted in Nova tangelos after storage for 4 weeks under the above conditions; however, extensive decay occurred in Robinson tangerines. Page hybrid had negligible decay after storage for 4 weeks at 34° and 40°, but slight decay was present at 45°. Lee hybrid showed opposite effects with slight decay at 34° and 40° but none at 45°.

### Quality Maintenance during Transport

Export.--Improper transit temperatures and relative humidities were observed to be the main causes of poor arrival conditions of U.S. perishable commodities in the Netherlands, France, and England. Improperly designed container vans, poor air circulation, and improper loading patterns resulted in either excessively low temperatures which caused freeze damage or excessive high temperatures which caused increased decay damage to the commodity. Other problems included weak packages, irregular delivery schedules, excessive physical damage, and high cost.

### Postharvest Physiology

Lemons.--Biphenyl residues in lemons are seldom over tolerance since the fruit absorbs one-third as much biphenyl as oranges when exposed to similar levels of biphenyl. However, lemons which have been injured by freezing or nitrogen storage absorbed excessive amounts of biphenyl indicating the involvement of a biological barrier. Biphenyl absorption by citrus occurred primarily in the rind tissue as indicated by the absorption of four times more biphenyl in separated orange peel than in separated pulp segments.

Oranges.--A procedure to quantitatively study citrus volatiles was devised which eliminates loss of the volatiles through absorption by septum or gasket materials. The rate of volatile loss through absorption by septum material is dependent on type of volatile compound and the molecular weight. Of the compounds tested, terpenes were absorbed most rapidly, about 90% in one hour. No detectable loss was noted in the all-glass apparatus which eliminated contact of volatiles with septum material. Endogenous volatiles emanating from navel oranges were measured by gas chromatography as a measure of quality. The longer the oranges were held in nitrogen the greater was the volatile production, both in the nitrogen atmosphere and after the oranges were returned to air. Production rates were obtained for ethanol, methanol, acetaldehyde, and ethyl acetate.

Mangos.--Research conducted under a P.L. 480 project at the University of Baroda, India, showed that a qualitative change in proteins and a considerable increase in total lipid and fatty acids occurred during ripening of mangos. Fatty acids and  $\beta$ -carotene regulated activity of glucose-6-phosphate dehydrogenase and 6-phosphogluconic dehydrogenase, but did not affect other enzymes. Activity of fructose-1-6-diphosphate phosphatase and glucose dehydrogenase increased during ripening but that of pyruvic kinase decreased. Pyruvic acid and cellulose decreased greatly during fruit ripening. Inhibitors were found to affect free enzymes of both mango and banana. However, ethylene inactivated the inhibitory activity of purified inhibitors of amylase, catalase and peroxidase.

### Postharvest Disease Control

Effect of mechanical harvesting on oranges.--Research conducted under a cooperative agreement at the University of Florida Lake Alfred Citrus Field Station showed that postharvest decay of clamp-mechanically harvested pineapple oranges was not significantly different than that of hand picked fruit when both received a benomyl fungicide dip. There were no significant differences in decay development after 10- and 17-day holding periods between hand picked and mechanically harvested fruit from benomyl-sprayed trees or postharvest dip treatments. Hamlin oranges from trees sprayed with abscission chemicals harvested by the clamp mechanical system had significantly less fruit damage but the benefits were cancelled by chemicals that burned fruit and reduced its marketability. However, mechanically harvested fruit treated with benomyl and thiabendazole (TBZ) without abscission spray had less decay than hand picked controls. Hamlin oranges harvested by the coil-shaker method had significantly fewer plugged and significantly more split fruit than those hand harvested. In these tests, abscission chemicals (erythorbic-citric acid mixtures) also significantly reduced the number of badly bruised fruit but caused extensive rind burn. Generally, mechanically harvested fruit from benomyl-sprayed trees had no more decay than hand picked fruit after a simulated shipping and sales period.

Effect of mechanical harvesting on grapefruit and lemons.--Marsh grapefruit harvested with the coil-shaker system following applications of abscission agents (cyclamate or cycloheximide) had increased cuts and punctures due to weakened peel apparently caused by chemical burn. No decay developed on fruit from erythorbic-citric acid sprayed trees. Severe chemical burn increased decay incidence of lemons which had been harvested with the coil-shaker system after abscission agent application.

Effect of degreening on tangerines.--Preharvest sprays of ethrel (2-chloroethylphosphonic acid) at 50 to 200 ppm were effective in reducing the chlorophyll levels of Robinson and Lee tangerines in Florida tests. Degreening was accomplished with no apparent injury to the fruit and generally without loss of fruit from abscission. The preharvest application of ethrel

shortened the postharvest degreening time that was necessary and resulted in proportionately less decay development during a holding period at 70° F. The washing of citrus fruit before degreening, which permits earlier fungicide applications, did not delay the loss of chlorophyll during degreening as had been reported in the literature. Robinson tangerines washed before degreening had an average reduction of over 50% in stem-end decay compared to fruit not washed before degreening. Likewise, mandarin-type citrus washed prior to ethylene degreening had less anthracnose than comparable fruit washed after degreening. Time of washing did not affect degreening.

Effect of controlled atmosphere on avocados.--No injury developed in fruit stored in a controlled atmosphere of 2% oxygen plus 10% carbon dioxide at 50° F. for 4 weeks after treatment at 115° for up to 10 minutes or at 120° for 8 minutes or at 125° and 130° after 1 minute. None of the heat treatments were effective in reducing decay during storage.

Promising new fungicides.--Thiabendazole applied as a flood gave better decay control than a non-recirculated spray, and water-wax applications in tests in five commercial packinghouses in Florida. All three methods of applying TBZ gave more effective decay control than the standard sodium orthophenylphenate (SOPP) treatment.

Grapefruit.--In five export shipping tests from Florida to Western Europe, TBZ was found to be more effective than SOPP and biphenyl in controlling grapefruit decay. Control was particularly striking on very ripe fruit shipped toward the end of the shipping season. Two of the test shipments received in Europe in April 1970 had less in-transit decay in fruit treated with 3000 ppm TBZ than in fruit treated with wax only, SOPP, or 1000 ppm TBZ. In all tests, residues of whole fruit was less than 1 ppm. At present, the acceptable TBZ residue level in the European Economic Community (EEC) is 2 ppm. Some of the EEC members have now accepted 6 ppm as the limit and it appears that this level will be acceptable in all the EEC countries in the near future.

Lemons.--Benomyl, another new fungicide, gave complete decay control in tests with ethylene-treated Florida lemons. Other fungicides in descending order of effectiveness were: 5-aceto,8-hydroxyquinoline sulfate, TBZ, 2-aminobutane phosphate, and SOPP. SOPP was not effective in controlling Diplodia stem-end rot, the most predominant decay.

Mangos.--Market quality of Tommy Atkins mangos ripened at 70° F. was not improved by waxing and often the fruit had poor color and increased decay. Prestorage dipping of Keitt mangos in 1000 ppm benomyl, 1000 ppm TBZ, or 1% 2-aminobutane resulted in no significant reduction in decay after 14 days at 55° and ripening for 4 days at 70°.

Market losses.--Studies in the Chicago market revealed that Alternaria citri is the causal agent for orange navel dry rot. Species of Alternaria, Penicillium, and Cladosporium occurred in 50% of the isolations from the diseased orange convolutions.

## Quality Evaluation

Ethanol content of juice as a measure of maturity.--Ethanol content of the fruit juice might afford a means of determining the optimum time of harvest. Ethanol content of juice of Robinson tangerines showed an increase of about 15-fold from 0.15 to 2.17 mg/100 ml during a 5-week period, while solids-acids ratio increased from 7.2 to 12.6. In October, juice of Hamlin on sour orange and Hamlin on Cleopatra mandarin rootstocks had ethanol content in juice of less than 0.1 mg/100 ml. By December, Hamlin fruit on sour orange rootstock had nearly 50 mg/100 ml and on Cleopatra rootstock over 30 mg of ethanol per 100 ml of juice.



## COTTON

## Determination of Quality

Fiber and yarn quality of 1968 cotton.--Preliminary analysis of data from experiments using three high quality cottons grown in the Southeast in 1968 shows results similar to those using 1967 crop cottons; namely, that fiber and yarn quality were reduced with excessive ginning.

Long staple Pima cotton harvested by spindle pickers had approximately 3 percent less manufacturing waste and quality of the fiber and yarn was more desirable than cotton harvested by strippers. Spinning performance was higher for spindle-harvested cotton. Cotton harvested before frost produced fiber and spinning qualities more desirable than cotton harvested after frost. Acala cotton had trends similar to Pima cotton, but method and time of harvest did not affect Acala as much as Pima cotton.

New instruments for determining quality.--Production testing lines for cotton samples were field tested at Hayti, Missouri, and Lubbock, Texas, using samples previously tested in the laboratory. Results show that average micronaire measurements were the same for the laboratory and the production lines.

Natural micronaire cottons (3.2, 3.7, 4.2, 4.7, and 5.2) processed as expected. Blend combinations, with average micronaire readings of 3.7, 4.2, and 4.7, were processed and several performed better than natural micronaire cottons with the same readings.

A cotton mix selected by linear programming was compared to a specific mix used by a mill. Spinning results showed that the linear programming mix produced yarn of equal quality to the mill standard mix. This can be helpful in purchasing cotton.

Sound and cotton breakage strength.--Acoustic and electronic equipment show that breaking cotton fibers in a bundle generates acoustic pressure pulses of varying magnitude depending on the strength of the individual fibers. Some fibers in the bundle do not break with sufficient sound to be recorded on present acoustic equipment and these fibers are being studied to improve the acoustical method of measuring fiber strength and fiber strength variability. The interrelation of fiber properties with machinery and processing parameters is being studied using the Magne Draft drafting system to verify and support work done on the Duo-Roth system in the Pilot Plant.

New instruments and methods for studying cotton quality.--Contracts were negotiated for developing devices to prepare fiber tests specimens representative of samples from which they were drawn. One contract was for a flat-bed type Fibrosampler with an improved combing and brushing system. The other contract was for a new and improved Fibrograph comb capable of functioning under a high-speed cotton fiber testing system.

A FS-2 roving Spin-Draft Tester showed that roving drafting-force variability is much less sensitive to drafting-force level than is spinning drafting-force variability. Front roll pressure is critical for the Duo-Roth drafting mechanism.

Serious production problems involving stickiness of cotton occur periodically during yarn manufacturing. Deposits accumulate and lead to lapping of cotton around spinning and other rolls. Research shows that certain noncellulosic constituents on cotton are definitely related to cotton quality.



## CUT FLOWERS AND ORNAMENTALS

## Quality Maintenance in Storage

Controlled atmosphere storage.--Controlled atmosphere storage proved to be both beneficial and detrimental to quality of various ornamentals studied in Florida.

Gladiolus corms which had been stored in a 2% oxygen, 3% carbon dioxide, and 95% nitrogen atmosphere sprouted later and yielded fewer flowers than did corms which had been stored in air or 20% oxygen plus 1% carbon dioxide.

Chrysanthemum cuttings which had been commercially stored for 1 month at 32° F. were injured in 5% carbon dioxide, but not in ethylene concentrations up to 1 ppm.

Gardenia blooms stored at 32° F. for 14 days were not adversely affected by 0.5 to 1 ppm ethylene. A 5% concentration of carbon dioxide delayed the onset of senescence, and when combined with 1.5% carbon monoxide, delayed senescence even further. Low oxygen (1%) was only slightly beneficial to bloom storage.

## Quality Maintenance during Transit

Chrysanthemums.--Chrysanthemum flowers which were successfully shipped by truck from Florida to Washington, D.C., in November opened satisfactorily after arrival when held at 70° to 77° F. The use of a flower preservative solution such as 2% sucrose with 200 ppm 8-hydroxyquinoline citrate (8-HQC) was essential for opening since buds did not open satisfactorily in water. The buds arriving at Washington with a flower diameter of 60-65 mm. enlarged to an average size of 105-110 mm. (a commercially usable size) in 4 days when held at room temperature in a preservative solution. Water uptake by the flower stems was maintained much longer in the preservative solution than in water. These shipping tests, which substantiated earlier laboratory studies at Bradenton, Florida, could lead to major changes in cut flower handling and shipping methods.

Carnations.--Carnation bloom "sleepiness" was effectively reduced during the 24-hour period required for air shipment from California and marketing in the east when a dry ice generator was used to maintain carbon dioxide concentrations between 10 and 20%.

## Postharvest Physiology

Roses.--Results of studies at Bradenton, Florida, on the synthesis of anthocyanin in roses showed that the outer petals of red roses did not synthesize additional anthocyanin after the flowers were harvested but became lighter red due to expansion of petals without additional pigment synthesis. However, the inner petals continued to synthesize anthocyanin after flower harvest. The inner and outer petals turned blue if cut stems were not held in sucrose, glucose, or fructose.

The incidence of vascular blockage in rose stems was reduced by cyclo-leucine, silver acetate, 8-HQC, and cupferron. Stems held aseptically at pH 6 had more vascular blockage than stems held at pH 4. Sucrose, glucose, and mannitol closed leaf stomata and increased fresh weight but mannitol did not prevent "blueing" of red petals.

The ethylene production per hour per 100 grams tissue at 68° F. was 2 to  $3 \times 10^{-5}$  milliliters for rose blooms.

Snapdragons.--In studies to determine the effect of preservatives on flower freshness, it was found that there was no difference in vase life of snapdragon spikes stored at 40° F. with cut ends held dry, in water, or in 8-HQC plus sucrose. Stored spikes did not last as long as freshly harvested spikes. However, spikes held in 8-HQC plus sucrose after storage developed more florets, greater fresh weight, and lasted longer than spikes held in water. Spikes held in light, in 8-HQC plus sucrose, or in 8-HQC without sucrose increased solution absorption while darkness and sucrose alone decreased liquid absorption. Florets of snapdragons held in light had more anthocyanin than florets held in darkness.

Chrysanthemums.--Woody stems were found to be detrimental to vase life of chrysanthemums. Flowers harvested with woody stems wilted before flowers with succulent stems. When flowers with succulent stems were held in water containing extracts from woody stems, they did not last as long as flowers held in water without the extracts. Flowers of most commercial cultivars when cut in the bud stage opened and developed as well in 8-HQC plus sucrose as did flowers held intact on the plant. However, bud-cut flowers held in the dark in 8-HQC plus sucrose did not open as well as flowers held in light in 8-HQC plus sucrose. When the leaves were removed the flowers did not open when held in 8-HQC plus sucrose in light. Solution absorption was greatly reduced in the dark or when leaves were removed from the stem.

Ethylene production per hour per 100 grams tissue at 68° F. was 20 to  $40 \times 10^{-5}$  milliliters for chrysanthemum cuttings, 2 to  $4 \times 10^{-5}$  milliliters for chrysanthemum blooms, and 4 to  $12 \times 10^{-5}$  milliliters for foliage. The ethylene production was increased 10-fold when decay was present.

Gladiolus.--Carbohydrates were more concentrated in gladiolus florets from winter bloomed spikes than in spring bloomed spikes. The floral preservative, 8-HQC plus sucrose, was effective in increasing the carbohydrate content of florets in the spring as well as in winter bloomed spikes.

Poinsettias.--Heat sealing of stems helped prolong the vase life of poinsettia bracts. Bracts on stems which were heat sealed and held in 8-HQC plus sucrose lasted longer than bracts on stems not heat sealed or stems heat sealed and held in water. All evaluated cultivars lasted longer in 8-HQC plus sucrose than in water.

Carnations.--Ethylene levels in San Francisco Bay flower packing areas, storage rooms, and air freight terminals were found to range from 40 to 200 parts per billion (ppb). Levels as high as 175 ppb were found in packed cartons of carnations before shipment. Ethylene production per hour per 100 grams tissue at 68° F. was found to be 100 to 300  $\times 10^{-5}$  milliliters for "sleepy" carnation blooms.

#### Postharvest Disease Control

Carnations.--Hot water treatment was effective in controlling gray mold of blooms. Dipping or drenching carnation blooms in 120° F. water for 30 seconds effectively controlled gray mold of carnation blooms and increased vase life 1 day. Injury from packing wet blooms was almost eliminated by shaking off the excess water prior to packing. Chlorine at 1 to 25 ppm in hot water reduced bacterial soft rot but removed some grayish bloom from the foliage.

## DAIRY PRODUCTS

## Determination of Quality

Bacteria detection methods.--A collaborative study is under way to compare the pH 4 toluidine blue and the periodic acid-bisulfite-toluidine blue strains with the Levowitz-Weber stain now recommended in "Standard Methods" for determining bacteria in dairy products.

A comprehensive survey was made of the bacteriological condition of milk and ice cream at various stages of handling and processing in India. Standard plate enterococcus and coliform counts were made. The initial quality of milk was low and postpasteurization contamination was high. Processing equipment was a source of contamination. Coliform and enterococcus counts were generally proportional to standard plate counts. A large number of coliform and enterococcus isolates were types. Salmonella, Shigella, and Serratia, all human pathogens, were found in the coliform isolates although the medium used is not favorable for these organisms.

Protection from Harmful Micro-organisms and  
Naturally Occurring Toxins

Detecting bacteria.--Cellulose acetate strips with Mylar backing were used for identification studies with some gram negative bacteria. The bacterial cells were broken up ultrasonically and the cell debris removed by centrifugation. Bacteria were readily distinguished at the generic level. More work is needed to determine if species or strains can be distinguished by this technique.

Protection of dairy products from bacteria.--Samples of orange essence oil (oil from orange juice) were tested for flavor in milk and for inhibitory properties against selected bacteria. The essence oil was similar to peel oil in all respects. Both impart a slight bitter flavor to the milk.

Analysis of data indicates that experimental survivor curves of heat-treated bacteria are seldom logarithmic as is commonly thought. Variations in shape of survivor curves can be explained on the basis of variations in distribution of heat resistance within a bacterial population. Survival of Salmonella anatum was shown to be greatly affected by the nature of the heating medium. The protective affect of some chemicals probably results from complexing with proteins in the bacterial cell, stabilizing them to heat.



## Protection Against Insects

### Biology, Ecology, Physiology, and Nutrition

Stored-product mite studies.--Samples of soft dog food infested with Tryophagus putrescentiae that were exposed to radio frequency treatment were observed for development for several months after treatment. A 17-second treatment (126° F.) was ineffective. At 21 seconds (136° F.) some mites survived and lived for several months but no reproduction occurred. There were indications the heat caused sterility. A food preservative, propylene glycol, has been evaluated as a mite control agent. The compound is used extensively in certain types of dog food. At concentrations of 4 percent and above reproduction is impaired.

New records of stored-product insects in Wisconsin.--The foreign grain beetle, Ahasverus advena (Waltl) and the dermestid Reesa vespulae Beal were recorded officially for the first time in Wisconsin. The identification of other insects of questionable taxonomic status is in progress.

### Biological and Physical Control

Insect response to pheromones.--Two approaches to controlling dermestids by means of pheromones have been demonstrated: (1) attraction and trapping of males and (2) inhibition and confusion of males followed by a reduction in mating. The latter method requires larger quantities of attractant than does the trapping method.

Considerable interspecific response occurs within Trogoderma spp. In a field test the T. inclusum attractant was effective in drawing T. sternale males from a natural warehouse infestation. It appears that a standard dermestid attractant can be developed.

Attractants of Trogoderma spp.--Milligram quantities of two of the sex attractants of Trogoderma inclusum, 14-methyl-cis-8-hexadecen-1-ol and methyl-14-methyl-cis-8-hexadecenoate, were synthesized. The trans isomers were also synthesized. Attempts at developing an improved synthesis were only partially successful.

Antimicrobial agents and food preservatives.--Butylated hydroxyanisole, BHT, and propionic acid, comprising 2 percent of the diet, caused high larval mortality, whereas 2 percent concentrations of sodium benzoate, methyl p-hydroxy benzoate, propyl p-hydroxy benzoate, n-heptyl p-hydroxy benzoate,

and sorbic acid seemed to reduce the number of larvae hatching from eggs of adults mated on treated media regardless of whether the adults themselves were raised on treated or untreated media. Citric acid and propyl gallate seem to have no effect.

Sex attractant of *Trogoderma glabrum*.--Several active components have been isolated from *Trogoderma glabrum* females. The compounds are closely related to those found previously in *T. inclusum*. The structure of one, the alcohol, appears to differ only in the cis-trans configuration. A homologue of the ester has also been discovered. Identification studies are in progress on other active fractions.

Constituents of cheese that attract mites.--Several methyl ketones extracted from cheddar cheese were attractive to cheese mites when recombined. None of the compounds alone was attractive.

#### Improved Insecticidal Control

Residual insect control treatments.--Coating agents such as floor waxes, paints, clays, talcs, paraffin and beeswax were evaluated for their compatibility with several insecticides. Talc and calcium carbonate were the most effective materials in retaining insecticide toxicity. Malathion was toxic to carpet beetles 36 weeks on talc and 22 weeks on calcium carbonate. Beeswax was the most effective compound tested on concrete that extended the toxicity of malathion.



## DECIDUOUS FRUITS, BERRIES AND TREE NUTS

### Quality Maintenance in Storage

Controlled atmosphere storage.--Apples.--Continuing CA research at Beltsville has shown that Stayman apples stored continuously in controlled atmospheres at 32° F. for 3, 5 and 7 months were consistently preferred by taste panelists over other lots of fruit stored in air or controlled atmosphere plus air storage. Apples from continuous controlled atmosphere storage were firmer, more acid, and had a lower respiration rate than those from air or controlled atmosphere plus air. Fruit from the various controlled atmosphere plus air storage regimes were of intermediate levels with respect to preference, firmness, acidity and respiration. These intermediate levels corresponded roughly with the duration of time the apples were in controlled atmosphere. In general, the longer the time in controlled atmosphere, the more closely the fruit approached the quality and metabolic state of fruit from continuous controlled atmosphere storage.

Peaches and nectarines.--Research at Beltsville in the market quality of CA-stored peaches and nectarines has shown decay to be severe in 1 nectarine and 3 peach varieties after storage in a series of storage regimes in which both the atmosphere and the temperature were shifted during the holding period. However, all varieties except Redskin were found to retain better quality in low oxygen-high carbon dioxide atmospheres than in continuous air storage. Redskin peaches were not of acceptable quality after 6 weeks in any controlled atmosphere or in air. Sunhaven and Redhaven peaches retained good quality through 6 weeks' storage in several of the controlled atmosphere-air combination storage treatments but not in air storage.

Late Le Grand nectarines stored 6 weeks in controlled atmosphere at 32° F. followed by 2 days in air at 65° and then 3 weeks in air at 32° retained excellent quality. An interrupted air storage with 3 weeks in air at 32°, 2 days at 65°, then an additional 3 weeks at 32° was one of the best storage treatments for nectarines. Sunhaven and Redhaven peaches and Late Le Grand nectarines all showed a consistent direct relationship between the extent of flesh discoloration and the total storage time in air. Redhaven peaches had good quality after 9 weeks in controlled atmosphere..

### Quality Maintenance during Transit

Strawberries.--Polyethylene pallet covers were tested in both truck and air shipments of strawberries from California to Chicago. On arrival, the truck-shipped pallets had atmospheres averaging 10% carbon dioxide and 11%

oxygen. However, when 6 pounds of dry ice was included, the carbon dioxide level was raised to 17.5-22% in the truck-shipped pallets and 22% in the air shipped pallets. Decay in truck-shipped berries averaged 2% on arrival and 3.5% after holding one day at 60° F. whereas in air shipped berries, decay averaged 0.5% on arrival and 1% in berries held one day at 60°. On arrival, cutting and bruising of berries averaged 14.5% in the truck shipments and 4% in air shipments. Overripe berries in the truck shipments averaged 6% on arrival.

### Postharvest Physiology

Pears.--Research in the Northwest showed that the reduction of organic acids in the fruit can be used as a good index to predict the occurrence of premature ripening of Bartlett pears. Fruits enclosed in temperature controlled limb cages and with a lower daily mean temperature had lower acid content than unenclosed fruit. An immediate reduction of both malic and citric acids occurred in the cooled fruit 3 days after beginning the cool treatment. Cooled fruit previously treated with the growth regulators gibberellic acid, 1000 ppm, or Alar (succinic acid 2,2-dimethyl hydrazide) 1000 ppm, had higher citric and malic acid content than untreated cooled fruit. There are indications that these growth regulators tend to overcome the cool temperature effect on pears. The immediate reduction of rate of citric acid accumulation and rapid decrease of malic acid were the earliest noticeable changes when fruit was exposed to cool temperature.

In research conducted under a cooperative agreement at the University of Maryland, 4 of the 12 volatile profile peaks produced by monitored pear fruit in controlled temperature chambers were tentatively identified as ethylene, acetaldehyde, ethyl acetone, and ethanol.

Apples.--In disease-related fundamental studies at Beltsville, pectin lyase (PL) from apple tissue rotted by Penicillium expansum was purified 106-fold by precipitation of the crude homogenate with 35 to 80% saturated  $(\text{NH}_4)_2\text{SO}_4$  and passage through a column of Sephadex G-100. Pectin lyase activity was maximum at pH 6.5 with 0.4% citrus pectin as substrate. Using pectin as the substrate at pH 6.5 with tris-acetate buffer,  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ , or  $\text{Mn}^{++}$  ( $2.5 \times 10^{-2}\text{M}$ ), each increased the reaction rate 25-fold. In citrate buffer, activity was equal to that using tris-acetate with  $\text{Mn}^{++}$ . Addition of  $\text{Mn}^{++}$  to citrate buffer did not increase PL activity. Pectin lyase was also detected in a malic acid-mineral salts medium in which the fungus was grown.

### Postharvest Disease Control

Major emphasis during 1969-70 was on determining the effectiveness of heated fungicides in controlling postharvest diseases. Results in this area have been very promising and the method has been adopted by the stone fruit industry in California.

Apples.--On eastern apples, heated suspensions of benomyl or thiabendazole used as postharvest dips (3 minutes at 113° F.) effectively controlled blue mold rot development in inoculated Golden and Red Delicious apples during 2 months' storage at 32° followed by 1 week at 70°. Heated tap water (113°) did not control decay. Heated fungicides controlled decay in either punctured or bruised apples, whereas, unheated fungicides controlled decay only in punctured apples. More fungicide was deposited on apples dipped in heated than in unheated fungicide suspension. Both benomyl and TBZ at concentrations of 1000 ppm were comparable with the commercial scald inhibitors ethoxyquin (2700 ppm) and diphenylamine (2000 ppm). No injury was observed on Red Delicious or Stayman apples dipped in any combination of fungicide and scald inhibitor and stored 5 months at 32° followed by a week holding period at 70°. Effectiveness of the fungicides and scald inhibitors was not altered when combined.

After 6 months' storage at 32° F., Starking Delicious apples had 48.5% surface scald on the check fruit, 5.2% on fruit dipped for 3 minutes in a suspension containing 2700 ppm ethoxyquin at 70°, and 1.6% on fruit dipped in a similar suspension at 80°. The percent of surface involved in 90°, 100° and 110° treatments was less than 0.2%.

Benomyl, 250 and 500 ppm at 70° and 110° F., and thiabendazole, 500 and 1000 ppm at 70°, and 250 and 500 ppm at 110°, all reduced blue mold rot of mechanically harvested Northwest apples by 75 to 95%. Fish-eye rot (Corticium centrifugum) was not controlled by any of the treatments. However, the degree of rot control was sufficient to make mechanical harvesting feasible for apples for processing.

Pears.--Scald on Anjou pears was significantly reduced on fruit treated for 3 minutes in 130° F. water. Neither benomyl nor thiabendazole reduced scald when used in 70° suspensions. However, at 125°, the higher concentrations of these materials improved scald control. Flesh decay of Anjou pears was substantially reduced by prestorage dips in 130° water, 125 and 250 ppm benomyl at 125°; 250 and 500 ppm benomyl at 70°; 250 and 500 ppm TBZ at 125°; and 500 and 1000 ppm TBZ at 70°. Stem decay was significantly reduced by all of these prestorage treatments and by a dip in 125° water.

The development of blue mold rot was greatly reduced in stored Eastern pears by a 10-second dip in a 500 ppm suspension of either benomyl or TBZ. Pears treated with either chemical developed less decay in punctured or bruised areas and in the stem-end than comparable fruit dipped in tap water. Rot development caused by Alternaria tenuis was not controlled by either benomyl or TBZ.

Fungus isolation data collected at Wenatchee indicates that Alternaria sp. plays an active role in the pear decay syndrome rather than being a chance contaminant as previously believed. The reduction in stem decay of fruit treated with heated fungicides can be attributed to control of Penicillium expansum by the fungicide and control of Alternaria sp. by heat.



The virtual elimination of P. expansum with unheated fungicides (70° F.) suggests that the fungus exercises a degree of biological control over Alternaria sp.

Peaches and nectarines.--Dip treatments of peaches and nectarines in 100 ppm benomyl suspensions at 70° and 125° F. or in water at 125° F. effectively reduced brown rot development during a 6-week storage period at 32° and a ripening period at 65°. Both hot benomyl suspensions and hot water gave better control of brown rot than a 70° benomyl suspension. Brown rot development on peaches was essentially the same in 21% oxygen with 0% carbon dioxide and in 1% oxygen with 5% carbon dioxide. Hot benomyl effectively controlled Botrytis and Penicillium decays but cold benomyl and hot water alone were only partially effective. The above treatments were less phytotoxic on nectarines than on peaches.

Postharvest decay of Eastern peaches was controlled with a 2½ minute dip in hot water, hot botran (100 ppm), or benomyl (100 ppm) suspensions 24 hours after inoculation with Monilinia or Rhizopus spores. Fungicide suspensions in 115° F. water were more effective than 115° water alone in controlling decay. However, suspensions of fungicides in 125° water were no more effective than 125° water alone for decay control. Unheated suspensions of benomyl effectively controlled brown rot, but did not control Rhizopus rot. Unheated suspensions of botran (2,6-dichloro-4-nitroaniline) did not control either brown rot or Rhizopus rot.

Combined fungicide and hot water treatments were more effective than unheated fungicide treatments for postharvest decay control in Western peaches and nectarines. Decay in fruit dipped for ½ minute in 125° F. water containing 225 ppm botran averaged 9.1% compared with 41.8% in unheated checks. A ½ minute hot botran (150 ppm) dip was as effective as a 1½ minute hot water dip. Benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate) was more effective than the other fungicides applied heated or unheated. A commercial 1½ minute, 125° hot water immersion treatment reduced losses due to postharvest decays by approximately 74%. A commercial hot botran treatment also was effective in controlling decay.

Preharvest applications of benomyl reduced the postharvest incidence of brown rot of nectarines (as well as plums). One preharvest spray alone was as effective as bloom sprays plus a preharvest spray. Preharvest benomyl treatments, however, did not fully protect fruit against postharvest decays and supplementary hot water or fungicide treatments after harvest were necessary for best control.

Related fundamental research conducted at Fresno showed that when ungerminated spores of Rhizopus stolonifer were treated at 120° F. with water, with 1% methanol, and with 1% methanol plus 100 ppm 2,6-dichloro-4-nitroaniline (DCNA), the median lethal dose (LD<sub>50</sub>) for spore germination was 192 seconds, 165 seconds, and 40 seconds, respectively. The LD<sub>50</sub> was 163 seconds in 0.1% methanol and 139 seconds in 0.1% methanol plus 10 ppm DCNA. At 68°, DCNA at either concentration had no significant effect on spore germination.



Strawberries.--Western strawberries (Z-5A variety) examined after 36 hours at 59° F. had significantly fewer losses from decay and injury when treated with 1580 ppm sodium dehydroacetic acid (DHA-S) dips at 120° (23.1%) than when untreated (42.1%). Berries treated with heated or unheated DHA-S at 5000 ppm were injured and suffered losses of 29.9 to 34.2%, which were not significantly different from the checks. After an additional 24 hours at 70°, losses in lots treated with heated DHA-S at 1580 or 5000 ppm applied as dips or showers ranged from 48.4 to 51.3%. This loss was significantly less than that in the untreated checks (72.1%).

Market losses.--Strawberry losses in the greater New York market were 6.4, 4.9, and 21.6% in wholesale samples, in retail stores, and at the consumer level, respectively. More than half of the loss at each level was caused by gray mold rot. Mechanical damage, especially of overripe berries in consumer samples, was another important loss factor.

Wastage in peaches marketed in the greater New York area from May to September totaled 1.8% in wholesale samples, 6.0% in retail stores, and 7.3% at the consumer level. Mechanical injury was the leading cause of loss in wholesale and retail samples; decay, principally brown rot, was the main cause of loss in ripened peaches of consumer samples and an important factor in wastage in retail stores.

### Quality Evaluation

Colorimetry.--Stayman apples harvested from replicated design plantings at a Winchester, Virginia, orchard were measured on the D25 tristimulus colorimeter. Apples from untreated trees or those treated with 1000 and 2000 ppm Alar spray (applied in the spring) had higher Hunter L and  $b_L$  and lower  $a_L$  values for skin color than those treated with 1000 ppm Alar spray applied in the summer. Significant differences in the ratio  $L b_L / a_L$  due to treatments and trees were found in November when the fruit were first measured but not in February. The ratio  $2000 \cos \theta / L$  was significant for treatments and trees for both months. Comparison of L values from February data, using Duncan's Multiple Range test showed a significant difference in flesh color between untreated control and 1000 ppm Alar (summer spray); Hunter  $a_L$  values for untreated control were significantly different from all Alar treatments. Hunter  $b_L$  measurements of flesh color of Stayman apples showed significant difference between untreated control and 1000 ppm Alar treatment applied both spring and summer as well as significant difference between 1000 ppm Alar spray in spring and 2000 ppm Alar spray applied in the spring.

Sonics.--Whole intact fruits such as apples, peaches, and pears display many natural resonances when vibrated in the sonic frequency region. One of these natural resonances is readily identifiable and reproducible. This particular resonant frequency (f) along with the mass (m) of each fruit is used in an expression,  $f^2 m$ , which is designated as an "index of firmness."

This factor,  $f^2_m$ , is directly related to the elastic properties of the fruit flesh and is correlated with textural changes associated with ripening of the fruit on the tree. In 1969, the firmness index,  $f^2_m$ , declined during maturation and ripening of Late Elberta peaches and correlated significantly with pressure test measurements ( $r = 0.90$ ,  $N = 30$ ). During the 1969 harvest season,  $f^2_m$  also correlated significantly with pressure test measurements ( $r = 0.67$ ) and sensory judgments of firmness ( $r = 0.68$ ) of Red Delicious apples which were picked over an interval from September 3 to October 10. Correlations between  $f^2_m$  and sensory firmness scores were not as high following extended storage as they were immediately after harvesting the fruit. The general trend of the results, however, indicates that high  $f^2_m$  values are associated with fruit having a high degree of firmness, whereas, soft fruit tend to exhibit low values for  $f^2_m$ .

The major advantage of this technique is that the firmness index,  $f^2_m$ , can be evaluated nondestructively. Tests on peaches also suggest that the technique may be readily adapted to automatic sorting of peaches for firmness.

Light transmittance.--A wide-range high-intensity spectrophotometer has been constructed for measuring the spectral absorption properties of intact fruits and vegetables. This unit incorporates matched interference filters mounted in a pair of wheels so that the sample is placed between two filters for measurement. With filters every 10nm from 380 to 880nm the spectrum can be recorded very quickly (2 to 3 seconds per scan). The use of a high-intensity source and a sensitive multiplier-type phototube permits measurements on samples having an optical density up to 10. The sample compartment is large enough to hold a cantaloup and samples as small as a cherry can be measured. A small digital computer is interfaced directly to the spectrophotometer for rapid data analysis. This unit will become our basic research tool for light-transmittance studies of intact fruits and vegetables.

### Protection Against Insects

#### Biology, Ecology, Physiology, and Nutrition

Biology, ecology, and behavior of *Oryzaephilus* spp.--*Oryzaephilus surinamensis* and *O. mercator* reared at 30° C., 80% relative humidity and no lights, had similar biological activity on oats, almonds, and raisins. *O. mercator* did better than *O. surinamensis* on prunes. High humidity and mold growth on raisins and prunes enabled both species to complete development on these fruits.

Identifying characters of *Carpophilus*.--Nearly 100 collections containing various species of *Carpophilus* beetles were made from several areas in the United States. Relatively few new species were found. Nearly all of the known economically important *Carpophilus* species which attack dried fruits and also those that are vectors of diseases that attack stone fruit trees appeared in the collections.

Ecology of mites on dried fruits and herbs.--Alkaloids do not have an adverse effect on the development of Tyrophagus putrescentiae.

Chance of food usually causes the first generation of mites to live for a shorter period than subsequent generations. Rhizoglyphus echinopus is very active in its population growth and can be compared with such other active species as T. putrescentiae and Carpoglyphus lactis.

Navel orangeworm ecology.--Studies on Paramyelois transitella (Walker), the navel orangeworm, were initiated by accumulating background information and studying field populations in relation to almond varieties and locale. Nuts were examined for infestation and adult insects were collected by light and bait trapping.

#### Improved Insecticidal Control

Drosophila control.--Pyrethrin thermal aerosols at  $\frac{1}{2}\%$  were ineffective against the dried fruit beetle and 68% effective against Drosophila in wine cellars.

Fumigation of dried fruits.--Fumigation of natural raisins in the laboratory with phosphine, methyl bromide and ethyl formate showed the former was sorbed least and the latter greatest.

Protectants for dried fruits in commercial storage.--Raisins which were dried on malathion-treated trays and then exposed to heavy insect infestation for one year passed industry quality tests. Those not dried on treated trays did not meet quality standards. Raisins dried on treated trays remained free of infestation during 11 months' storage with no further preventive treatments. Quality of such raisins exceeded those which were protected by fumigation.

Effect of malathion on reproduction of Plodia.--Studies on the effects of malathion and of light and temperature cycles on oviposition of Indian-meal moth, Plodia interpunctella (Hübner) were completed. Data are being analyzed. The time of egg deposition by the Indian-meal moth under warehouse conditions was determined.

A preliminary test to determine the resting locations of the Indian-meal moth indicated that untreated and malathion-treated kraft paper may serve as a barrier and/or effective method of protecting stored almonds against infestation.

Protectants for tree nuts.--Inshell almonds treated with malathion at the rates of 4, 8 and 16 ppm were protected from insects through 11 months of storage.



Fumigation of stored nuts.--Six fractions of processed almonds fumigated with methyl bromide at the rate of 3.5 lbs/M cu. ft. heavily sorbed the fumigant. Sorption rate varied from 52.7% in roasted nutmeats to 87.3% in almond meal.

Control of navel orangeworm.--Bioassay tests to determine dosage-mortality response of navel orangeworm, Paramyelois transitella (Walker) were conducted with mature larvae. Malathion, Gardona, and Fundal were tested.

Sixteen foaming agents were tested. Three appear promising. Dichlorvos was incorporated into one foam. Amounts needed will probably require the insecticide to be applied, then covered with foam.

#### Insect-Resistant Packaging

Packages for dried fruits.--Pouches made of 1-mil polypropylene-saran-1 $\frac{1}{4}$ -mil polyethylene containing prunes had 1 pouch out of 12 examined infested. This is superior to any other pouch now being used by the dried fruit industry. An instrument which measured air leakage in raisin packages produced data that correlated significantly with resistance to infestation by packages exposed to infestations. A new polyethylene coated carton shown to be resistant to infestation is now used by 3 packing companies.



## GRAIN, INCLUDING RICE

## Maintenance of Quality

Storage fungi.--Deterioration of rice in storage causes serious losses to the rice industry and these losses are reflected back to the producer. Storage molds represent a major cause of deterioration of quality.

The development of storage fungi was studied with Nato and Blue Belle rough rice in small-scale aerated bins. The rice was put in storage at moisture contents of 15-16%, aerated at rates of 0,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , and 1 CFM per barrel from August 6, 1969 to March 2, 1970. There was no significant increase in the percentage of kernels of Nato rice invaded by storage molds except in the nonaerated sample. In Blue Belle rough rice, storage molds increased significantly in all bins, with the rate of increase correlated inversely with the rate of aeration. In both varieties, the predominant storage fungi were species of the Aspergillus glaucus group. Species of the A. flavus group were a significant portion of the flora only in the non-aerated bin of Blue Belle rice on the last sampling date (208 days of storage). Field fungi remained viable in most kernels throughout storage. A. ochraceus was capable of rapidly degrading rice starch. A. ochraceus liquified rice substrates in about 14 days at 25°C. Other storage fungi, including A. oryzae, do not usually liquify the rice substrate before growth and enzymatic activities approach zero. Continued studies have verified that A. candidus is the most efficient competitor in invading rough rice if the rice is at equilibrium with a relative humidity of about 90% or higher.

Grain dust.--Dust is an important storage factor in grain which is a recognized health and fire hazard. Workmen who unload grain cargo require higher pay, thus increasing the cost of export grain. A method to determine dust in grain was developed based on a new principle. The dust is evacuated from a 200-g. sample by means of a uniquely designed funnel and then trapped in distilled water. The dust is filtered, quickly dried, and weighed. A more rapid method consists of measuring the increased conductivity of the water with a conductivity bridge. The increase is brought about by the soluble minerals in the dust particles. Conductivity correlates very highly with dust content. Other storage factors under investigation on the stored corn and wheat are (1) germination, (2) fat acidity, (3) sedimentation, (4) fat content, (5) mold, (6) falling number, (7) GADA (glutamic acid decarboxylase). The falling number and alpha amylase tests were used in evaluating the magnitude of the sprouted wheat problem in the Pacific Northwest.

## Determination of Quality

Protein test.--Research is continuing aimed at developing improved methods for grading and determining quality of grain. These methods should be rapid, accurate, reproducible, and inexpensive. New test methods are being sought. The rapid copper carbonate test for determining protein content in wheat, corn, oats, barley, and grain sorghum was evaluated this past year by testing over 600 samples of grain from 21 field offices of the Grain Division, C&MS. An improvement was made in the method by employing a sonifier to disengage the protein cells from the ground meal. Since no additional reaction time is needed for the protein to react with the copper when the sonifier is used, the total time for performing the test was reduced to about 5 minutes.

Effect of radiation.--To study the effects of radiation on the milling and baking quality of wheat, samples of No. 2 hard red winter wheat were irradiated at two dose levels. Controls and irradiated wheats were analyzed, milled, and processed in the baking laboratory. After 2 weeks, 1 month, and 3 months of storage no significant changes were noted. Six lots of wheat which were infested with insects, stored in Savannah, Georgia, for 3 years, then irradiated at two dose levels were analyzed. The fat acidity was high as would be expected of wheat which had been stored for 3 years. Radiation treatment apparently had no effect upon milling quality. All samples milled equally well but had higher than normal ash content for hard red winter wheats. No significant differences in control and irradiated samples were noted for bread baking quality factors or physical dough testing qualities. Strong gluten quality was indicated. No objectionable odor or taste differences were noted.

Lipid content.--Colorimetric methods for measuring the lipid content of grain are being investigated. These procedures are adaptable to automation and therefore desirable in marketing inspection. The possibility of converting the colorimetric method for determining fatty acid content of grain to automation is also being explored. Some dyes were found to differentiate between sound and damaged germs in grain. These are being tested to determine the degree of deterioration which can be measured, and testing procedures are being developed.

Damaged grain.--Methods of determining quality factors for grading should work equally well for fresh grain and stored grain. Biochemical changes take place in the grain during storage. Studies of the effects of damage on separation of lipids by thin-layer chromatography show similar compositional patterns for sound and damaged grain. However, fatty acids appear in larger amounts with most types of damage. The effect of irradiation on lipid composition is being studied by thin-layer chromatography and near infrared spectrophotometry. No significant differences have been noted between the irradiated and nonirradiated wheat. The samples are stored and will be checked periodically for differences in composition which may appear with storage time.

Stinkbug damage.--Stinkbug damage on soybeans causes a decrease in oil content and an increase in percent of free fatty acids, thus affecting their market value. Rapid tests for estimating the extent of damage are needed. The decrease in density of soybeans with stinkbug punctures is the basis for two methods of determining the extent of damage. In one method the mean time of fall of the beans between two fixed points in a vertical column of water is determined. In the other the percent of beans that float in a saturated salt solution is determined. The correlation between damage and protein content is poor.

Automatic bushel weight test.--An automated bushel weight tester for grains was developed under MQ contract research. A total of 5,600 tests were made in evaluating the new bushel weight tester against the manual device currently used on corn, barley, oats, grain sorghum, soybeans, and flaxseed. Results were very satisfactory on all grains. Bushel weights for both methods agreed within 0.1 lb. or less on all grains except flaxseed and soybeans. A change in the shape and area of the hopper funnel opening probably will correct this discrepancy. Differences in test weights attributed to operator error generally were not significant. The automatic device requires less than half the time needed by the manual procedure and with considerably less work. Only minor difficulties were encountered in its operation.

Heat damage.--A partial reflectance laser beam method can distinguish sound wheat from some heat-damaged samples; however, results using a colorimeter method show greater potential for evaluating heat-damaged samples than the laser method. Moisture adsorption data of sound, broken, moldy and heat-damaged corn samples show differences in rates and in equilibrium moisture content. Infrared photographic analysis of corn shows some promise of differentiating sound, moldy and heat-damaged samples. X-ray radiographs of corn kernels repeatedly soaked and dried reveal that the greatest number of fracture planes are formed parallel to the long axis but are oriented randomly in an angular distribution about the axis. A rectangular press for producing KBr pellets for infrared analysis was developed. An improved response is obtained using rectangular pellets instead of the common cylindrical pellets.

Bean color standards.--The problem of color change of standard samples with time and exposure to light was investigated for the Grain Division, C&MS. Bean samples held in sealed glass containers under 7500K illumination at ca 475 f.c. for 1 month was measured every 2 weeks to follow changes.

Germ damage.--Time studies on the grading of wheat, sorghum, rye, oats, and corn having germ damage and no germ damage by seven inspection stations show considerable time savings of a bleaching method over the conventional method. Correlation between the bleaching method and the



standard method was significant at the .001 level ( $r$ , 0.8757). Correlation coefficients were highest for the studies using wheat and lowest for the studies using sorghum. Chemical analysis of bleached and unbleached grain showed that ash increased while protein and crude fiber decreased after bleach treatment. Correlation tests between glutamic acid decarboxylase and percent germ damage in bleached and unbleached samples gave higher  $r$  values for germ damage determination made on bleached grain. A similar test using percent germination gave higher results when correlating percent germ damage on bleached samples than was found on unbleached samples. The hand barley pearler does an excellent job removing the germ covering from wheat, sorghum, and rye in less than a minute. A method using the hand barley pearler has enabled whole germ to be easily broken out of the sorghum kernel. Treatment of corn by soaking in bleach enables the germ to be easily removed.

Moisture content.--A modified Tag-Heppenstal instrument for determining grain moisture with adjustable spring-loaded rollers was designed and constructed, and checked with corn, soybeans, and sorghum for calibration. A regression analysis gave good calibration curves in the 5-30% moisture range for corn and the 5-20% range for soybeans. The calibration results for sorghum showed more scatter than desirable. Using a Motomco moisture meter, a poor correlation existed between kernel moisture and capacitive reactance alone or resistive loss alone. A fairly good correlation existed between oven moisture content and the ratio of resistive losses to capacitive reactance. A tentative calibration curve for an instrument of this type was derived.

Grain odor.--Different fungi are responsible for different odors when grown on wheat. Nearly all strains of *Aspergilli* produce urinal, putrid, and fusty odors. In the case of *Penicilli* the dominant odors are fusty and earthy. For the fungi imperfecti class the fusty odor appeared most pronounced. For bacteria, odors were most often urinal and putrid, but in the case of *Streptomyces griseus* an earthy odor was dominant. All odors were analyzed by gas chromatography. The majority were found to give characteristic sets of peaks and this suggests that the method can be of use for the analysis of microbial infection of grain.

Chemical methods for detection internal insects infestation.--The DBQ (2,6-dibromoquinoeclormide) reagent for detecting methyl-p-benquoquinone and pyrocatechol, and thiazine red for detecting insects were evaluated and found to be of no value in detecting internal insect infestation. The ninhydrin-collidine test shows a good correlation with the X-ray test of rice weevil infected wheat kernels. Comparing the X-ray, Ashman-Simon and Dennis-Decker systems, the X-ray technique for detecting lower insect forms is quite pronounced. Both ninhydrin tests failed to detect ova or early larval stages. Ninhydrin tests with milo could not be accomplished in the Ashman-



Simon device because of the kernel hardness. Preliminary tests for rice weevil on oats was made without regard for the quantitative ratios of weevils to grain. The presence of husks interfered with removal of weevils after the inoculation period and also with expression of juice from infested kernels. Test results with the angoumois grain moth parallel those observed for rice weevil infestations.

Broken kernels.--Results of comparison tests made last year of the Stein grain breakage tester were evaluated. The indication of breakage was measured by using the standard sieve test for broken kernels, the more sample remaining on the sieve the less the breakage. Breakage increased with decreasing moisture content for all of the grains tested. Artificially dried corn showed a greater tendency toward breakage than air dried corn. The test results were sufficiently consistent to warrant recommending the Stein unit for test purposes.

New test for determining yeast quality.--The test fills a need for distinguishing any drops in gassing rate of refrigerated yeasts both compressed and ADY (active dry yeast). Expanding the test to four different sugar reagents permits identification of the particular enzyme of the yeast, maltase, sucrase or zymase, which might have undergone deterioration.

Grain sample divider.--Construction and testing of electronic control system for the automatic grain sample divider was completed. The system consisted of a modified Daytronic 300 D transducer driver-amplifier with a Type L limit control output module and Type 72 X two channel differential transformer input module. The Daytronic weighing system was adapted for automatic operation by constructing an auxillary automatic switching unit and connecting it into the Daytronic manual switching circuits. The automatic weighing cycle was controlled by a program controller constructed to include part of the Daytronic set-point controls. A weighing cycle counter was constructed to control the number of weighings of each size sample per cycle. The electronic control system was tested using a mock-up of the mechanical system.

Sorting rice electronically.--An optical-electronic device has been developed that has the capabilities of scanning and sorting a rice sample at high speeds. A concentrated effort has been made to develop a mechanical device capable of handling and orienting rice kernels at high speeds. The most successful system developed employs two flat metal endless belts traveling in the same direction and speed, at an angle of 45° to each other with the apex of the angle downward. A small space between the belts allows the kernel to travel in the "V" and be inspected by the optical sensing device. The arrangement provides proper orientation and allows the kernels

to remain at rest with respect to the forward motion while being measured. A second set of belts, traveling at a slower linear speed is used to obtain spacing between kernels on the belt passing over the optical sensor.

Physical detection of internal infestation.--A new X-ray anode current stabilizer and a more efficient mechanical kernel handling mechanism were developed in the past year. The newly designed kernel handling mechanism utilizes an inclined indent plate which positively feeds individual seeds to a vacuum pick-up wheel that transports the kernel over the X-ray beam for inspection. A concentrated effort to locate a suitable solid-state low energy X-ray sensor has resulted in a major breakthrough. A manufacturer of photo sensitive devices cooperated in developing a solar cell highly sensitive to X-rays. Tests of several commercial X-ray contrast agents failed to indicate that any was more suitable than barium chloride.

Grain color.--Data on color of four wheat classes (HRS, durum, SW, and SRW) were developed and analyzed. Hunter L and b color readings are positively and significantly correlated. Thus, a light sample is likely to appear more yellow than a darker one. Because of the relation between L and b, factors should be correlated with both L and b to a similar degree. Total defects, test weight, vitreous kernel content, and protein content have a significant effect on sample color, while ash and moisture content showed no significant relation with L, b, or a color value. Correlation coefficient between Hunter L value and barley color score, L and percent plump, L and percent thin kernels, b and percent plump kernels, and b and percent thin kernels were all highly significant. Year of growth and the varietal difference were insignificant, while location of growth was significant at the 1% level. Increasing sample depth decreased all three Hunter readings (L, a, and b). Background color had no effect on sample readings except when the sample depth was small. When kernels were fixed in a crease-up position, L and a values were lower, and b was higher than when the kernels were fixed with the crease down. Small kernels, which had a higher pigment content than large kernels, yielded low L and b Hunter values.

Weevil damage of peas.--A method has been developed which greatly reduces the number of peas which must be individually examined in determining extent of weevil damage. Peas containing weevil larvae have a lower density than uninfested peas. It is necessary to examine only those peas which are separated by flotation in a salt solution of a certain concentration.

Milling yield of rice.--The design principles needed in developing a single device which will, in one operation, determine the milling yields of rice were studied. Temperature of the rice increases a minimum of approximately 50°F and a maximum exceeding 80°F in the McGill miller. These

large temperature increases are suspected to contribute to decreases in head yields, especially in adverse ambient temperature-relative humidity conditions. Forced air cooling of the rice while in the McGill miller has failed to reduce breakage. Breakage appears to be related to the moisture content of the rice and ambient air conditions. An X-ray study of rough rice showed that much of the rice is already broken before processing through milling-yield machinery. High speed movies have been used to pinpoint some of the milling-yield operations which cause the breakage. The McGill sheller broke from 2.8 to 5.2% of long-grain varieties and less than 0.5% of the medium-grain varieties. Probably the single most inefficient operation in the present method of milling-yield determinations is the sizing operation, i.e., separation of head rice and broken kernels.

Moisture determination.--The effect of experimental parameters on the elevated temperature DTA studies of water release from oats, sorghum and wheat were examined. A total of 31 thermograms were obtained on whole, cut and crushed samples. Water release was diffusion controlled and dependent upon the physical form of the sample. Also, the thermograms suggest that water release from sorghum and oats occurs in two steps, while dehydration of wheat occurs in a single step. The evolution of nonaqueous volatiles and chemical reactions resulting in water production are sources of error in oven moisture assay in grain. The identity and amounts of gases evolved and the extent and nature of chemical changes producing water are being determined for corn. Carbon dioxide and ammonia are the principal gases evolved. A Maillard type reaction between reducing sugars and amino acids gives  $\text{CO}_2$ , water and volatile aldehydes, acids, and alcohols.

New hardness tester.--The Brabender hardness tester and the barley pearler were modified to permit the use of an electronic strain measuring and recording system. Comparison tests are presently being run with the two hardness testing units using different varieties of wheat.

Grain sampling.--A hopper with a partition dividing it in half was built for evaluating the design of diverter type samplers. Dyed grain is placed in one compartment and undyed grain in the other. The grain stream discharged from this hopper consists of 50% dyed and 50% undyed grain. Using high speed movies and analysis of the sampled grain it was determined that the diverter takes a larger percentage of the sample from the portion of the grain stream nearest the transporter mechanism. Tests were conducted to determine if the bucket elevator segregates particles of varying size and weight upon discharge. There is on the average, 0.9 lb/bu difference in the test weight between the lot closest to the head pulley and the lot farthest away. Efficiency of the Static mixer for mixing free flowing solid particles was studied using a radioactive tracer technique. The tracer is produced by irradiating the grain with a neutron flux. Since



the tracer is built into the grains, surface and physical properties of tracer grain are the same as the unirradiated grain. Several static mixers were constructed and evaluated. The Static mixer is convenient and easy to operate for free flowing solid particles. Analysis can be achieved by using gamma-ray spectroscopy without disturbing the final mixture.

Use of light to measure composition.--The development of a rapid, accurate method for measuring the oil, protein, starch, and moisture content of grain and oilseeds is a major goal. Previous work has shown that light-transmittance techniques can be used to measure moisture content and we have now explored the same techniques for analysis of oil, protein, and starch content. The spectral reflectance and transmittance properties of ground soybeans and the major components of oil, starch, protein, and water have been characterized for the 0.8 to 2.4 micrometers range. These measurements indicate that either reflectance or transmittance can be used to measure the composition of ground soybeans. Both techniques require spectral measurements at 6 or more wavebands using a bandpass of less than 10nm for each. The transmittance technique is more precise but requires an accurately dimensioned sample and the use of carbon tetrachloride. The reflectance technique requires a much simpler sample preparation, but the photometric analysis must be more precise. We believe the reflectance technique will be used for field instruments and the transmittance technique for laboratory applications. An instrument capable of making either the reflectance or transmittance measurement has been developed and is being tested. The total analysis including grinding of the sample requires less than 5 minutes. These techniques of analysis should have application to all grains although tests have been conducted only on soybeans.

High-moisture grain analysis.--The evaluation of the moisture content of corn and other grains having very high moisture content is a problem because present instruments are not reliable for moisture contents above 35%. Nuclear Magnetic Resonance techniques have been shown to be accurate for moisture contents up to 100%, but instruments for these measurements have been complex and expensive. A less expensive, simple-to-operate-instrument based on the NMR principle became available recently and was tested for oil and moisture analysis of corn and soybeans. This instrument showed good agreement with moisture content as determined by oven drying over the range from 12-70% moisture for corn. Oven-dried samples of soybeans were analyzed for oil content by the NMR and compared with standard extraction procedures. The standard error was  $\pm 0.25\%$  in oil content. The only sample preparation is the weighing of the sample and measurements can be made in less than 2 minutes. This NMR instrument cannot distinguish between oil and moisture so the moisture must be removed for an oil measurement.



## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Aflatoxin detection.--A screening method employing chromar sheets for assaying aflatoxin in corn was developed. Aflatoxin is removed from a representative 210 g. sample of ground corn dockage by appropriate solvents. The extract is then filtered, evaporated to near dryness, and streaked on 1,000 $\mu$  thick chromar sheets. The sheets are developed for fluorescent bands, which are indicative of aflatoxin.

A light reflectance technique for differentiating species of Aspergillus by the color of their spores was developed. Fungal spores collected from grain grown on agar and eluted with solvents were filtered. The light reflectance spectra of the spores on the filter paper were recorded. The curves of several species differed from one another. Trace element impurities which interfere with aflatoxin production by Aspergillus flavus can be present in ordinary distilled water. A. flavus 15517 yielded 12.7 to 15.4 mg of aflatoxins per 100 ml when grown on a chemically defined media using double distilled water and highly purified components. The same medium without purification precautions yielded less than 1 mg/100 ml. New isolates of Aspergillus have been screened for production of aflatoxins. One isolate tentatively identified as A. versicolor produced about 13 mg of B<sub>1</sub> and B<sub>2</sub>, combined, per 100 ml on a 20% sucrose, 0.7% yeast extract plus salts medium. This is the first time that a species of Aspergillus other than A. parasiticus, A. flavus, or A. oryzae has been found to produce such a large quantity of aflatoxin. Studies in this laboratory of toxic and nontoxic strains growing on different media have indicated that under some conditions higher yields of kojic acid than aflatoxin are produced and under other conditions both kojic acid and aflatoxin yields are high. These results suggest that they both may require very similar conditions for their formation or a possible relationship between their biosynthetic pathways, but these data cannot support the contention that kojic acid is a precursor of aflatoxins.

Aflatoxins in mice.--Aspergillus flavus isolates produced aflatoxin in significant amounts only when the relative humidity was in excess of 84-85%. Toxic isolates of Penicillium viridicatum produced abundant amounts of toxin in liquid media only in unshaken cultures. When a rice culture of this fungus was fed to mice as 10% of the diet, clinical symptoms were observable in most mice after 5-7 days. Toxic effects of P. viridicatum in mice and rats can be partially offset by about 0.3% tetracycline in the diet. Mold-free storage was obtained when nontransferred dryerated corn with 18.5% moisture was aerated with 0.7 cfm/bu in a downward direction for the first 24 hr, then in an upward direction. Corn with 16% moisture had a slight moisture accumulation and mold problem at the surface when aerated with an upward flow of 0.5 cfm/bu. Insulating the bins helps prevent moisture transfer. Transferred dryerated corn with 14.5% moisture was safely stored

for 6 months with 1/30 cfm/bu airflow. Longer storage would require about 0.1 cfm/bu. Field shelled corn with 19.5% moisture was stored safely for 8 months by continuous aeration at 0.5 cfm/bu or by refrigerated storage at less than 40°F.

Fungi and stored-grain insects.--Aspergillus flavus was found to be the predominant fungus in Sitophilus oryzae breeding in rice. The eggs of S. oryzae, Trogoderma granaria, and Corcyra cephalonica were found to be free of fungi although all other stages of the insects carried fungi internally. Grain infected with A. flavus was found to have a retarding effect on the developing of S. oryzae. A. flavus and the toxigenic Penicillium islandicum are carried internally by Corcyra cephalonica breeding in rice flour.

Aflatoxins in sorghum.--No aflatoxins were detected in 74 lots of sorghum sampled at grain storage facilities in production areas and at terminal elevators. Species of Aspergillus flavus group were isolated from about 0.6% of the seed. The aflatoxin-producing ability of 40 isolates were tested on substrates of cottonseed, peanut, rice, and sorghum. Sixty percent produced no aflatoxin, 22.5% produced trace amounts, and 17.5% produced significant amounts on one or more substrates. More aflatoxin was produced on sorghum substrate than on cottonseed, but less was produced than on rice and peanut. Generally storage fungi were a minor fraction of the mycoflora of sorghum grain. Field fungi were associated with up to 95% of some samples. Alternaria spp. were quite prevalent. Among the storage fungi, species of the A. glaucus group were most common. Several cultures of A. candidus were isolated, one produced small quantities of fluorescent compounds similar to some claimed to be toxic to chickens.

### Protection Against Insects

#### Biology, Ecology, Physiology, and Nutrition

Biology of the Angoumois grain moth.--It was demonstrated that the Angoumois female adults produced a definite sex attractant to males, and that the attractant could be used to study behavior of the moths. Internecine activities were studied and further details of intraspecific competition were obtained. A pure breeding red-eyed strain was developed and is being maintained. This has potential use as a genetic marker in mating studies. Satisfactory control of Pymotes in Angoumois cultures was not attained. Larvae developed most rapidly when feeding on the germ rather than endosperm of the grain (site of feeding). Studies are in progress to determine if there are strains of fast and slow developing moths. Bulgur was less susceptible to infestation by the Angoumois moth than was whole wheat. A

comparative study on the biology and behavior of the life cycle of the moth when reared on various tissues of the grain kernel was made to evaluate the nutritive values of the media.

Water regulation physiology and stress.--Computer programs have been used to statistically analyze the effects of different cations and CO<sub>2</sub> on water absorption from the rectal lumen. Carbon dioxide significantly reduces the absorption of water from experimental solutions by rectal epithelial cells. Potassium ions caused significant increases in water absorption when the insects were placed under CO<sub>2</sub> anesthesia.

Studies on the effects of humidity on water regulation and metabolism of mealworms were continued with Tenebrio molitor larvae starved for 3 weeks at various relative humidities from 0-90. Findings indicated that the mealworms did not maintain a constant ratio of water to dry matter, that the larvae did not utilize more dry matter at lower humidities, that water loss or gain was dependent on humidity, and that lipid loss as a percent of total dry matter lost increased at 60% RH and was also somewhat higher at 90% RH. No particular fatty acid was utilized preferentially.

Distribution of hazardous microorganisms.-- The ability of Salmonella montevideo to persist throughout the life cycle of Plodia interpunctella was investigated. One-week-old larvae were placed in S. montevideo contaminated wheat. After pupation the adults were placed in a non-contaminated environment and eggs were collected. Eggs laid by the contaminated adults were contaminated, but S. montevideo could not be isolated from the emerging larvae.

The effect of contamination level on the ability of stored grain insects to become contaminated and to transmit S. montevideo is currently being investigated.

Effect of dockage on grain insects.--Studies showed that saw-toothed grain beetle adults have a preference for clean wheat over that containing 1-4% dockage.

Ecology of grain insects.--Stimulating influences by such factors as "out-of-condition" grain, other insects, size of test chamber, and fresh grain had a greater influence on the distributional and ovipositional response of rice weevil than on lesser grain borer.

Insects in whole wheat products developed by WURDD.--Free-choice tests showed parboiled, lye-peeled acetic acid and benzoic acid neutralized WURDD wheats were the least attractive for feeding and oviposition of five whole wheat products developed by WURDD. Pearled wheats of 73% and 88% recoveries were the most attractive.



Insects in bulgur.--Tests to determine amount of damage done by single larvae of Indian-meal moth, almond moth, and raisin moth were completed. A 1967 whole wheat, a 1967 whole bulgur, and a 1965 whole bulgur were tested by placing newly-hatched almond moth or raisin moth larvae in separate small plastic boxes with 140 kernels of medium. There were six replicates of each medium. Only the 1967 wheat and 1967 bulgur were used with the India-meal moth in this test. Causes are unknown, but the 1965 bulgur was much more suitable for the almond moth (also for the Indian-moth in previous tests). The raisin moth survival was very poor, or nil, in all media. Generally, there were nearly twice as many bulgur kernels with >90% of the germ removed by a single larva than for wheat. As previously reported, this is no doubt partially due to some of the bran over the germ and some of the germ having been removed by abrasion during processing. Also, the developmental period is longer in bulgur which may result in more feeding during larval development. The number of bulgur germs >90% destroyed during complete larval development was approximately 63/larva while approximately 30 wheat kernels sustained such damage by each larva. The numbers of insects used in this test were small, but there is evidence that there are differences in moth susceptibility among lots of bulgur, and that the moth larvae developing in bulgur devours more food than those developing in wheat.

Insect survey in Uttar Pradesh.--A survey of insect infestation in different zones of Uttar Pradesh, India, was conducted. Samples of wheat, maize, and paddy were brought to the laboratory for analysis of quantitative and qualitative losses. This year's work was devoted to assessing: (1) weight loss of grain, (2) loss of germination, (3) estimation of avoidable losses by EDB fumigation, (4) effect of insect feeding on protein content, and (5) effect of type of storage structure and zones on non-reducing sugars of grain and free fatty acid values. A study of insect population in different zones in relation to type of structure being used by the farmers for storage of different grains was also conducted. The loss in weight found due to insect feeding in paddy and maize varied from 0.16 to 5.87% and 0.91 to 10.86%, respectively. A decrease in the protein content was evident in the germ and endosperm-eaten kernels of maize, but there was an increase in the protein of infested paddy kernels.

Development of insect populations in rice.--Degree of milling of rice was found to affect population development of rice weevils, lesser grain borers, confused flour beetles, and Indian-meal moths. Removal of more bran in milling resulted in a smaller number of progeny developing. Varietal effects were observed, but differed for each insect species. Varietal effects on insect infestation of rough rice are also being investigated.



Constituents of rice that attract insects.--Recognition of a set of components in food which as a whole contributes to the chemosensory response of insects and mites is a significant finding. Some of the components attractive to Sitophilus zeamais in fractions of rice were characterized as several carboxylic acids, ketones, aldehydes, and esters.

#### Biological and Physical Control

Insect resistance in corn varieties.--Endosperm variability analysis for maize weevil resistance among dent corn lines was continued. Data are being analyzed to provide information on the inheritance of weevil resistance. Preliminary analyses of data show that maize weevil resistance may be primarily a function of additive effects, with the most emphasis being placed on maternal inheritance.

A total of 102 new collections of races of maize from Brazil were evaluated in replicated experiments for resistance to the maize weevil. Approximately 20 of the lines tested had 10 or fewer progeny per sample as well as less kernel weight loss than susceptible checks. The susceptible checks had more than 100 progeny per sample with a substantial loss in kernel weight.

Resistance of varieties of grain sorghum.--A study of the effects of nine sorghum varieties--90-day White, NK-150, Ordinary White, and Texas Martin from South Africa; CPS-86 and M-35-1 from India; Ordinary White from Somalia, on four aspects of the biology--egg and larval infestation, mortality of the immatures, rate of development, and longevity of the rice weevil, Sitophilus oryzae (L.) and the maize weevil, S. zeamais (Motsch.) revealed: (1) Varietal differences existed in overall infestibility and in effects on specific aspects of the insect's biology; (2) where rice weevil was concerned, rate of increase (reproduction and/or development) was highest in the softest varieties and lowest in the hardest varieties; (3) infestibility tended to be higher in softer varieties but one of the hard varieties (South African White) was also severely attacked; (4) the maize weevil was similarly but less strongly affected by varietal differences; and in the case of rate of development at low relative humidity, varietal effects were altered; and (5) differential oviposition rates, not larval mortality, was indicated as an important varietal effect along with differential rates of development and longevity.

Varietal differences as an ecological factor.--The intrinsic rate of natural increase of T. granarium was calculated on different wheat varieties. Represented in descending order according to tests which evaluated suitability for insect development were test varieties: C-273, C-306, S-308, K-227, and PV-18.

Insect-resistant wheat varieties.--During this past year 400 varieties of wheat were tested for resistance against the rice weevil Sitophilus oryzae and the lesser grain borer. Out of the varieties screened, eight varieties, viz., E4007, E5574, E7856, E5994, PI. 157932, E7289, E672, and Nainari-60 were found to be resistant to the rice weevil and 12 varieties, viz., PI. 163428, E3026, E4974, E5856, PI. 164154, PI. 163433, E4193, E4278, E4220, E4249, E4040, and E6010 were found to be resistant to the lesser grain borer.

Active substances produced by the khapra beetle.--Fatty acid derivatives are being prepared for attractancy tests with Trogoderma granarium, the khapra beetle. No information on the results of the tests is available.

Diapause in Trogoderma.--During this reporting period additional tests were conducted which confirmed that faecal lipids induce diapause in Trogoderma larvae. It was also found that feeding on wetted, room dried wheat and maize flours induced diapause in Trogoderma larvae.

Effect of temperature and humidity.--The resistance of S. granarius larvae to low temperature ranges at various humidities was studied. Results indicated that the larvae were more cold-sensitive than the imagos.

#### Improved Insecticidal Control

Insect control in railway boxcars.--Eight tests involving a total of 73 railway boxcars were conducted. The most promising material was a 2½% dichlorvos spray. Caged test insects, Tribolium castaneum, were used with the tests. A mortality of 100% was achieved in those cages having only insects while 99.5% were killed in cages in which the insects were embedded in wheat shorts.

Candidate protectants on wheat.--Phoxim (BAY 77488) on 12.5% wheat gave kills superior to the standard application of malathion.

Dichlorvos for moth control in wheat.--Indian-meal moth adults and eggs were killed upon exposure to dichlorvos vapors but second to fifth instar larvae were only slightly affected. Maximum residues to 0.25 p.p.m. dichlorvos were found on wheat exposed to 2.0 PVC strip per 1,000 cubic feet at 70°F and 39% RH.

Malathion on farm-stored wheat.--Studies are being conducted with malathion-treated farm-stored wheat to determine the effect of retreatment on level of residue.

Phosphine fumigation of wheat.--Phosphine studies in gas-tight containers showed that phosphine concentrations are reduced when held in the presence of grain.

Malathion aerosol treatment of corn.--Nine 3,250-bushel metal bins were treated with malathion thermal aerosols applied in conjunction with grain aeration. An ultra low volume 95% malathion formulation proved to be as effective as the carbon tetrachloride formulation. Laboratory studies indicate that sorghum and wheat are more difficult to penetrate than corn. Other studies with dichlorvos indicate that airflows of 2.5 c.f.m. per bushel are necessary before the vapors penetrate 8 feet of grain. Tests with Bay 77488 indicate it is as effective as malathion when applied as an aerosol.

Dichlorvos for moths in corn.--Maximum residues of 0.87 p.p.m. dichlorvos resulted from the surface treatment of corn stored in 3,250-bushel metal bins exposed to two PVC strips per 1,000 cubic feet overspace at 70°F and 39% RH. A maximum of 0.20 microgram dichlorvos per liter of air was found in the overspace.

Candidate protectants for corn.--Phoxim (Bay 77488) protected corn from infestation by four insect species. GLC analyses indicated little degradation of phoxim residues over a 12-month storage period. Further evaluations of CIBA C-9491 on corn are being made.

Dichlorvos strips to control moths in corn.--Dichlorvos-impregnated resin strips were suspended in 14 3,250-bushel bins of corn in Kansas in field tests comparing dichlorvos strip, dichlorvos spray, and a mixture of synergized pyrethrins and malathion for the control of Indian-meal moth. Residue studies were conducted over a period of 6 months. More than 30 bins were treated and observed for infestation in Nebraska. All treatments continued to show some degree of Indian-meal moth control after 12 weeks. The strip-treated corn was found practically moth free, while in some bins of untreated corn, there were 50 or more adult moths per square yard.

Candidate protectants for grain sorghum.--Phoxim (BAY 77488) at dosages as high as 20 p.p.m. did not prevent the emergence of rice weevils and lesser grain borers from heavily infested sorghum but the adults were killed upon emergence and reinfestation was prevented by dosages as low as 5 p.p.m. C-9491 did not prevent the emergence of rice weevils and lesser grain borers and reinfestation by both species was achieved in the treated grain. Reinfestation by the rice weevil in sorghum treated with 20 p.p.m. C-9491 progressed very slowly. Applications of phoxim at dosages as low as 5 p.p.m. on uninfested 12.5% sorghum gave better protection against four insect species than malathion at the standard rate of application over a 12-month period.

Malathion protectant on rice.--Small-bin tests of three varieties of rough rice each treated with 1.0, 1.5, and 2.0 pints of malathion per 1,000 bushels revealed protection against rice weevil, confused flour beetle, and lesser grain borer invasion for 6-12 months. Residues in rough rice exceed 8 p.p.m. for up to 3 months, in hulls for 7-11 months, and in bran for 6-10 months. Residue levels in bran and milled rice were affected by variety of rough rice, being greater in Belle Patna, intermediate in Nato, and least in Dawn. These varietal differences were due to characteristics of the hull of each variety.

Dichlorvos protectant on rice.--Dichlorvos was found effective for disinfecting rough rice and for providing short-term protection against reinvansion by rice weevils and lesser grain borers. The duration of protection afforded by dichlorvos, but not its initial disinfection effects, was adversely affected by high moisture content of the rice. Residues after treatment of rough rice with 5, 10, and 15 p.p.m. were as high as 7.3 p.p.m. in rough rice 24 hours after treatment, but in 30 days they were 0.87 p.p.m. in rough rice, 3.1 in hulls, 0.41 in bran, 0.03 in brown rice, and 0.02 in milled rice.

Phoxim residues.--BAY 77488, its oxygen analog, and two possible metabolites have been synthesized, separated, and detected by using thin-layer and gas chromatography. A F&M 609 gas chromatograph has been modified to accommodate a phosphorous detector and is used for the analysis of the insecticide. A Micro Teck GC is being used as a prep GC to separate and collect the components of the technical grade product.

At least six components have been found in technical BAY 77488. Sulfotepp is present along with the parent compound. The other components are presently being identified. It is imperative that all components of tech 77488 be identified and the quantity present before a critical study of the metabolites can be conducted. At this time it is not known whether the impurities in 77488 are due to the manufacturing process, degradation on storage, or both.



Fate of malathion residue on grain and in grain products.--The degradation rate of malathion appears to have a turning point at about 14% moisture, degrading at higher moisture levels. Malaoxon was not found as a degradation product in the grain or in bread made from flour from treated grain. It was however determined to be an intermediate oxidation product during degradation. Steps in degradation were elucidated to the end products, phosphoric acid, monoethyl phosphate, and dimethyl phosphate.

## MEAT AND MEAT PRODUCTS

## Maintenance of Quality

Rigor of meat.--In the presence of  $\text{Ca Cl}_2$ , sucrose inhibits myosin ATPase activity which supplies the energy necessary for the formation of the rigid actomyosin complex. Sucrose does not have a significant effect on myosin ATPase activity when  $\text{Ca Cl}_2$  is not present.

Sheep carcass quality.--Data have been collected and are being analyzed in a cooperative study with the American Sheep Producers Council to determine shrinkage, quality change and growth of microorganisms on chilled ovine carcasses of various yield grades during shipping.

## Determination of Quality

Muscle quality studies.--Purified samples of beef muscle glycogen were analyzed for outer-chain lengths and degree of branching to try to relate structural changes to flavor. Volatiles from lamb kidney fat were trapped and are being analyzed for composition by mass spectroscopy.

Muscle fiber area of Black Angus steers generally increased in size between 12 and 24 months of age. The fiber area decreased during 10 days aging of the carcass. Sarcomere length increase was not as directly related to maturity as was fiber area. Animals up to 5 years of age have been slaughtered and the carcasses are being evaluated for amino acid, lipid, mineral and palatability changes.

Meat from animals slaughtered properly and improperly were studied to see if meat slaughtered by approved methods could be identified. The hemoglobin-myoglobin ratios, pH and bacterial counts are being analyzed for the preparation of the final report by researchers at Texas A&M University.

Preliminary observations show the following tendencies in a comparison of quality of beef from bulls and steers. Bulls gain more rapidly, have larger rib eyes but less fat and are less tender than steers. Steers have finer texture, brighter color and higher grade than bulls.

Preliminary results indicate that female bovines contain less connective tissue than males. In calves and young bovines the differences in tenderness of the particular muscles are not reflected in connective tissue content. In young bovines protein content was the same in all muscles examined. Water content was sex dependent.

Research was initiated to identify and evaluate body measurements of beef cattle in relation to weight gains, tenderness, flavor and muscle-bone and muscle-fat ratios. Hereford, Charolais and Angus breeds of various body sizes will be evaluated.

Detection of meat extenders.--Soy proteins added to luncheon meat products, at the 1% level, can be detected by electrophoresis using thin slabs of polyacrylamide gel. The use of polyacrylamide rather than starch gel simplifies the electrophoretic analysis. Commercial soy protein is available in the form of flour, concentrate, or isolate. The flour and isolate produce a characteristic band which is made up of a slow moving high molecular weight protein. Although the concentrated form of soy protein does not produce this band, its presence can be detected by the increased size of a band common to flour and isolated protein. (These protein bands are not produced by luncheon meat extracts containing beef and pork). Variation in commercial preparation of luncheon meats will necessitate the procurement of samples from different processors and regions in order to corroborate these findings.

#### Protection from Harmful Microorganisms and Naturally Occurring Toxins

Spoilage bacteria.--Spoilage bacteria and members of the Aspergillus flavus group found on animal products can be differentiated according to species and strain by pyrolysis-gas-chromatography. These studies suggest that this new method will have wide application in rapid detection, enumeration and identification of food microorganisms and their metabolites.

## OILSEEDS, INCLUDING PEANUTS AND COTTONSEED

## Maintenance of Quality

Moisture distribution in peanuts.--Partial differential equations that predict the simultaneous transfer of oxygen, carbon dioxide, moisture, and heat as a function of time and position in a peanut kernel have been simplified to an appropriate form for solution purposes. Computer programs have been written and solutions obtained with the aid of the digital computer. Laboratory equipment has been designed and built to experimentally determine the value of certain parameters related to oxygen diffusion which are required by the above equations.

Studies were conducted to evaluate the diffusion equation as a model to describe the moisture content as a function of time and position in a peanut kernel and peanut pod. Results show that the diffusion equation representing a homogeneous body accurately predicts the drying rate of peanut kernels and the diffusion equation representing a composite body of concentric spherical shells accurately predicts the drying rate of peanut pods.

Peanut taste tests.--Because of the move to the National Peanut Research Laboratory in Dawson, Georgia, it was necessary to select and train a new flavor panel. Seventy candidates were given a series of 6 screening tests. A panel of 15 was selected and given additional training.

The off-flavor problem associated with spin-blanching peanuts before roasting was investigated. Results showed that the off-flavor was primarily due to oxidative rancidity in the oil. Other tests indicated that a chemical change or breakdown had occurred in the kernels.

Cottonseed oil pigments.--Gossypol and pheophytin were combined and found to react similarly to an undesirable dark pigment found in refined cottonseed oil. This was demonstrated by thin-layer chromatography. The resulting product was adsorbed by bleaching earth and appeared to be a mixture of pheophytins and the gossypol reaction product similar to that in the refined oil.



## Determination of Quality

Peanuts and aflatoxin.--The percentage of aflatoxin-free kernels  $F(0)$  in lots of shelled peanuts is an important parameter in computing probabilities associated with sampling for aflatoxin concentration. The variance of 5 or more sample means from each of 164 commercial lots of shelled peanuts contaminated with aflatoxin were analyzed to estimate  $F(0)$ . A regression analysis of the relation between these estimated values and the average level of aflatoxin M found in the lots showed  $F(0) = 99.9765 - 0.0031 M$ . Observed distribution of 10 sample means from each of 11 aflatoxin-contaminated commercial lots were compared to the negative binomial distribution by means of the Kolmogorov-Smirnov Test. The test did not reject the hypothesis that the two distributions were the same. A commercial sampler conforming to specifications developed by this project was tested in a peanut shelling plant. As a result of these tests, automatic samplers meeting these specifications have been approved for taking official samples of shelled peanuts. Poisson, negative binomial and normal distributions have been generated with the aid of a digital computer to help estimate the effect of particle size and subsample size on subsampling errors associated with aflatoxin analyses.

Peanut metabolism.--Temperature and maturity effects on peanut lipid metabolism during curing have been investigated. Immature kernels exhibited increased lipid synthesis when moisture content was above 42-47%. Lipid degradation became predominant below 42-47% moisture content and continued until the moisture content became limiting on metabolic activity at approximately 10-15%. When initial kernel-moisture content was maintained by high relative humidity, lipid synthesis was dominate throughout the test period. In mature kernels initial moisture content was below 45% and lipid degradation was dominate throughout curing. Irrespective of curing temperature similar patterns were obtained, but the effects were greater at 50° and 22°C. Quantitative changes in the volatiles of unshelled peanuts stored under typical warehouse conditions and of shelled peanuts stored under controlled environmental conditions were determined using GLC. The unshelled peanuts had the highest volatile content with maximum values for both conditions found in peanuts stored 90 to 120 days. Pentane, acetaldehyde, and methanol accounted for 80-98% of the volatiles present and were primarily responsible for total volatile changes.

Peanut blanching.--A simple device for blanching peanuts was designed and built. The blanching is done with high pressure air directed into a device constructed of two funnels. A 250-gram sample is uniformly blanched in 2 minutes. A device for measuring the moisture profile of peanuts was developed. Preliminary tests indicate that this measurement may show damage done by drying peanuts at too high a temperature and may also be related to maturity. A new procedure for the measurement of peanut oil stability and the degree of oxidative rancidity build up was developed.

Cottonseed and aflatoxins.--Aflatoxins were not detected in cottonseed stored at 30°C and in relative humidities of 85 to 90%, respectively, during a 7-week storage period. Seed stored under the same conditions after inoculation with spores of a known aflatoxin-producing strain of Aspergillus flavus developed only trace amounts of the toxins in 85% RH in 4 weeks. However, after 2 weeks in 90% RH, the inoculated seed contained the toxins in a concentration of ca 200 ppb and in 4 weeks, the concentration peaked at more than 4,000 ppb. Variation of moisture content among individual seeds was determined during exposure to atmospheres of differing relative humidities. After 63 days in storage, the range between high and low moisture contents of individual cottonseeds frequently exceeded 1.5% and occasionally exceeded 5.0%. Aflatoxins, ranging in concentration from trace to 184 ppb were detected in 4 of 65 samples of seed collected primarily from seedhouses at gins and oilmills. A. flavus was isolated from less than 0.5% of the seed. The aflatoxin-producing ability of 33 cultures was determined on different natural substrates; 84.8% of the cultures produced significant amounts of aflatoxins on one or more substrates.

Moisture and oil measurements in soybeans and cottonseed.--Soybean samples from various parts of the country were submitted to MQ's Instrumentation Research Laboratory for analysis for moisture and oil by a new spectrophotometric instrument in comparison with NMR and infrared methods. Further improvements in the official method for measurement of oil content in soybeans of the American Oil Chemists' Society have been developed. Several samples of cottonseed have been analyzed for oil content at two moisture levels in an effort to determine the effect of this factor on the analysis.

#### Protection from Harmful Microorganisms and Naturally Occurring Toxins

Detecting Aspergillus flavus on peanuts.--Tests in which kernels identified to contain Aspergillus flavus growth by visual examination were cultured showed that the inspectors were about 92% accurate when they identified A. flavus growth on peanuts.

Because aflatoxin is produced in peanuts by A. flavus, the U. S. peanut industry conducts a program in which lots of farmers' stock peanuts identified to contain A. flavus kernels are designated segregation 3 and diverted to crushing for oil. Lots not found to contain A. flavus kernels and with low levels of damage are designated segregation 1 peanuts. Studies were continued to test the efficiency of this method for detecting lots with high concentrations of aflatoxin.

Survey of peanuts for fungi.--Spanish peanuts from the 1969 crop year in the Southwest were sampled from harvest until spring. Nine of the 56 samples contained aflatoxins in concentrations ranging from <6 to 170 ppb.

Species of the Aspergillus flavus group were isolated from 12.4% of the kernels. The range of prevalence per sample was 0 to 90%. Significant amounts of the toxins were produced by 94% of randomly selected isolates on one or more of four substrates. Peanut was the most favorable substrate for toxin production, averaging 1-2/3 times more toxin than rice, the next best substrate. Of these isolates, 97% were identified as A. flavus, 2% as A. tamarii, and 1% as A. parasitius. A total of 134 samples from the 1969 crop of rice in the Southwest were collected from industry drying and storage facilities from harvest to spring. All samples were free of aflatoxin contamination. Species of the Aspergillus flavus group were isolated from slightly less than 1% of the kernels. Of 127 isolates, 5.5% produced significant amounts of toxins on one or more substrates. A. flavus was found on 83.5% of the isolates. Dry spores of an aflatoxin-producing strain of A. flavus have remained viable after storage at room temperature for 127 days. There was no change in the ability of the fungus to produce aflatoxin.

Detecting aflatoxin in peanut butter.--Work was started on adapting the millicolumn procedure developed by MQ for use in detecting aflatoxin in peanut butter. Cooling the peanut butter to about 35°C before extracting appeared to improve the aflatoxin band and reduce the interfering material. Further improvement of the procedure for quantitating the millicolumns was made by transferring the silica gel containing the aflatoxin band from the millicolumn to a disposable pipette plugged at the small end with a piece of glass-fiber filter paper.

Varietal resistance to aflatoxin.--Previous work has indicated that there is a difference between varieties of peanuts in their susceptibility to aflatoxin contamination. A test was set up to determine if the inhibition to mold invasion was due to some chemical agent in the peanut skin or kernel, but none was found.

New mycotoxins in peanuts.--A new method was developed for the detection and quantitation of griseofulvin and dechlorogriseofulvin by gas-liquid chromatography. This compound is a metabolite of Penicillium urticae and was originally suspected of being related to the aflatoxins because of its similar  $R_f$  on thin-layer chromatographic plates. Two metabolites, o-methylsterigmatocystin and its dihydro derivative, were isolated from a non-aflatoxin-producing strain of A. flavus and identified. The dihydro derivative had not been previously reported. Sterigmatocystin and related compounds are purported to be possible biosynthetic precursors of aflatoxins. A metabolite from an ochratoxin-producing strain of A. ochraceus has been isolated and purified. Preliminary data indicate that the compound is an isocoumarine type compound. A new metabolite, previously unreported, has been isolated from a Rhizopus species and is in the final stages of identification.



Efficacy of electronic color sorting of peanuts.--The efficacy of electronic color sorting followed by hand sorting as a means for removing aflatoxin-contaminated kernels from commercial lots of shelled peanuts was tested. A 200-pound sample was taken from each of 12 commercial lots previously found to contain aflatoxin. On the average 75% of the aflatoxin was removed from the lots by removing 13% of the peanuts by electronic sorting. Removal of 0.2% more of the kernels by hand sorting removed an additional 18.4% of the original aflatoxin content of the lots. The average aflatoxin content in the lots after sorting was 4.4 parts per billion (ppb) compared to an average input of 85.7 ppb. The data show that the success of sorting is quite variable from lot to lot. For example, only 73.8% of the aflatoxin was removed from one lot while 100% was removed from others. This variability among lots indicates that it would be beneficial to test a sample before reworking an entire lot. The test would indicate whether to electronically sort without hand sorting, electronically sort with hand sorting or go to blanching with subsequent electronic sorting and hand sorting.

Cottonseed and aflatoxins.--The results of a second year of survey for growth of A. flavus and presence of aflatoxins in cottonseed followed the pattern found during the first year. Aspergillus niger predominated in the dry areas and A. flavus in the hot, humid areas with aflatoxins a real problem in the latter area only. A more comprehensive survey is needed.

In a pilot study on the effect of storage conditions on cottonseed one lot containing 1,000 ppb aflatoxin B<sub>1</sub> was stored at two temperature and three moisture levels favorable for growth of producing molds. Cottonseed will be removed at intervals to ascertain the relation of storage conditions on Aspergillus flavus growth and aflatoxin content. A ferric hydroxide cleanup method for determining aflatoxins in cottonseed was developed. Use of this method results in yields of higher aflatoxin content in stored cottonseed as compared with the present official method. This method will be adapted to other products.

### Protection Against Insects

#### Biology, Ecology, Physiology, and Nutrition

Feeding habits of insects on soybeans.--Confused flour beetles were found unable to reproduce in whole, cleaned, 12.5% moisture soybeans. When 17.5% splits or splits and bean meal were present, reduced populations reached maturity but a second generation was not produced. Other contaminants such as weed seeds, corn, and sorghum permitted development and reproduction until they were depleted.



## Biological and Physical Control

Radiation for peanut insect control.--Progeny of the red flour beetle and saw-toothed grain beetle in inshell and shelled peanuts were reduced or eliminated by 10 krad of radiation. Higher levels were completely effective against these insects. Indian-meal moth, however, had some survival even from 20 krad but control was complete with 40 krad.

## Improved Insecticidal Control

Dichlorvos strips to control moths in soybeans.--Maximum residues of 0.38 p.p.m. dichlorvos were recovered from samples of soybeans 0-2 inches deep exposed to 2.0 PVC strips per 1,000 cubic feet over space at 70°F. and 39 percent relative humidity. A maximum of 0.20 microgram dichlorvos per liter of overspace air was found during an 18-week storage period. Indian-meal moth larvae on the surface were not killed by the dichlorvos vapors, but when confined to 2 to 3 layers of soybeans in open cardboard containers, other larvae of the same ages were killed by spraying with 20 p.p.m. dichlorvos, based on the weight of soybeans 2 inches deep.

In September, dichlorvos impregnated resin strips were placed in 15 3,250-bushel metal ASCS bins in Illinois. It was found that (1) dichlorvos was deposited on the exposed beans in very slight amounts even at three times normal dosages, (2) 1X, 2X, and 3X dosage rates were effective against the adult moths, and (3) the 3X dosage did not control the larvae appreciably better than the 1X dosage.

Fumigant evaluations for soybean insects.--Fumigation of 8-bushel lots of soybeans with EDC-CCl<sub>4</sub> (75:25) resulted in residues of each component in the hull and interior portion of the soybeans. Flaking of the dehulled soybeans was ineffective in removing the residues. EDC-CCl<sub>4</sub> residues were detected in the miscella and in the hexane condensates recovered during evaporation-stripping of the oil from the miscella and from desolventizing of the soybean meal. No residues were found in the extracted oil or the desolventized meal.

Insect protectants for peanuts.--Combinations of dichlorvos and malathion were evaluated as protectants for farmers stock peanuts in small bin studies. The combinations were effective in controlling the initial insect infestation. Dichlorvos-malathion combinations also provided better residual protection than malathion during the 12 months of storage.

An experiment is in progress to evaluate dichlorvos, Gardona, and a combination of the two as protectants for farmers stock peanuts. Heavily-infested peanuts were treated in replicated intermediate-scale bin studies. Dichlorvos alone, and in combination with Gardona, provided excellent control of the initial insect infestation at all dosage levels tested.

Dichlorvos strips for peanut insect control.--Dichlorvos-impregnated resin strips were effective for moth control on farmers stock peanuts during the first 2 months in small-scale warehouse experiments. The strips gradually lost effectiveness during the third month; however, moths were unable to become established on the peanuts during the 6-month experiment. Dichlorvos, at the rates tested, had no effect on the control of beetles.

Phoxim as a peanut protectant.--Phoxim continued to give excellent protection to farmers stock peanuts in replicated large-scale experiments. No live insects were found in probe samples taken 6 months after treatment in any of the three rates of application. Samples from the malathion treatment had an average of 1.6 insects per 1,000 grams.

## POULTRY AND POULTRY PRODUCTS

## Maintenance of Quality

New packaging methods.--Fryer chickens, packaged in either high permeability (polyethylene) or low permeability (vinylidene) packaging film, stored in a CO<sub>2</sub>-atmosphere or air, were evaluated after storage for microbiological condition and oxidative deterioration (rancidity). Microbial counts were affected slightly by type of packaging film, but not to a statistically significant extent; they were, however, significantly higher in polyethylene packaged birds than in vinylidene, but atmosphere or temperature of storage did not significantly affect rancidity development. Rancidity development as well as microbial count is important in selecting storage conditions and packaging systems for chilled poultry.

## Determination of Quality

Salmonellae detection.--An inexpensive apparatus for use in detecting salmonellae in poultry and egg products was developed and evaluated. The system, based on the selective motility principle, utilizes a pint Mason jar. Two U-tubes each containing a semisolid medium and overlaid with a nutrient broth project through a rubber stopper into the enrichment broth in the jar. Using mixed cultures, the system was shown to be as effective in detecting salmonellae as the more expensive Banwart Flask. The effect of (1) type of enrichment broth test (1 hr or 2 hr) on the development of Salmonella agglutinations was studied. Of 16 carbohydrates tested, on each of 20 Salmonella species, sorbitol and dulcitol resulted in the greatest number of agglutinations. A 24-hour incubation period for growth of salmonellae coupled with a "2-hour" H-agglutination time resulted in the greatest number of agglutinations.

## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Heat and chemical resistance of bacteria.--The heat resistance of Streptococcus faecalis in liquid whole egg and yolk was determined. Mean "D" values for this organism in whole egg were 8.4, 5.1, and 3.6 at 57.5°C, 60°C and 62°C, respectively. Corresponding "D" values for plain yolk were 33.2, 14.9 and 10.6. These data indicate that the presence of fecal streptococci in pasteurized egg products would not necessarily result from post pasteurization contamination.

Studies aimed at developing practical methods for destroying or inhibiting the growth of Salmonella on fresh market poultry have been initiated. The susceptibility of salmonellae to photodynamic action with and without sensitization by dyes is being explored. A literature search to obtain fundamental and practical information on this subject is underway.

Contamination and infection levels of Salmonella in poultry flocks from prior to placement of day-old chicks to processing at 9-10 weeks of age were determined. The influence of type of litter, (new, old and composted) on levels of Salmonella infection was also studied. Although only two serotypes--S. simsbury and S. st. paul--were isolated from feed, litter, water and cloacal samples during the grow out period of one flock, an additional 4 serotypes were found during processing. In two flock studies, the frequency of isolation of salmonellae diminished during the course of the broiler grow out period both in birds and in the environment. No definite effect of type of litter on level of Salmonella infection was found.

Injecting chlorine at levels up to 40 ppm into wash water for eviscerated broilers resulted in significant reduction in microbial counts. Birds washed with unchlorinated water showed log counts of 3.2, while those washed with 40 ppm chlorine added showed log counts of 2.5. Cooperatively with T&F personnel, an improved final carcass washer was developed.



## SEEDS

## Maintenance of Quality

Seed storage experiments.--The relationships between root growth and storability of almost all crop seeds seems to be very poor. Even where there is a remote relationship the differentiation in root growth is not nearly as well defined as the germination data for seed lots in storage. Water absorption tests with onion seed did reflect a difference in the rate of water uptake. Differences were not so evident after 16 hours imbibition. It is questionable whether this difference is enough to result in the slow germination observed for some seeds. Respiration measurements made on selected alfalfa seed lots indicate that the R. Q. at 4 hours after imbibition gives some indication of storability. The poorer storing lots tended to have a higher R. Q. at this time.

Continuing studies on 47 seed kinds show that seeds stored in aluminum lined packages maintained satisfactory germination over a 5-year period. Color changes in a number of species was more rapid at higher moisture levels. In cress seeds no color change accompanies death but in some other seed kinds color change occurred after death. Thus, it is not possible to establish any firm relationship between seed color and viability. The genetically controlled tendency of runner bean seeds towards hardseededness was determined by drying lots to low moisture contents, which increased hardseededness. It was possible to differentiate between stable and unstable hardseededness. Control of the hardseeded condition appears to reside in the external layers of the seed coat.

Interactions between harvest maturity, storage conditions, and germination methods were determined for several kinds of grass seed. Seeds of Poa pratensis harvested in the early dough, late dough, and ripe stages germinated well, even after prolonged storage. Best storage was at 25°C at a moisture content of 7-8%. The most favorable germination method was alternating temperatures between 20 and 30°C, a prechill period of 7 days, and treatment with 0.2% KNO<sub>3</sub>. With Trifolium repens early harvest results in a decrease in germination. The earlier the harvest, the lower the storage temperature should be for seeds of about 10% moisture. However, the storage temperature should not go below freezing. Seeds of Vicia sativa should be harvested as early as possible. The seeds should be stored at temperatures below 25°C. The differences in physiological responses during germination by the different species illustrate the heterogeneity of the reaction to environmental factors in connection with endogenous conditions.

Wheat seeds lose their ability to utilize glucose-U- $^{14}\text{C}$  for  $^{14}\text{CO}_2$  production and for carbohydrate and protein synthesis faster under poor storage conditions than under better conditions. This decrease in glucose-utilizing capacity occurred primarily in the endosperm and preceded any decrease in germination or growth. Electron microscopic examination of cells from wheat embryos infected with storage fungi of the Aspergillus glaucus group showed that lipid bodies (sphaerosomes) coalesce to form large amorphous masses within the cell. This amorphous mass might represent the fatty acids which accumulate in seeds infected with storage fungi. Neither glucose utilization, germination, nor growth experiments were able to predict storage potential (as determined by accelerated-aging) of barley seed lots. An unknown growth inhibitor, which is a water-soluble ethanol-insoluble cation, has been isolated from Abrus precatorius seeds. This compound(s) inhibits both root and shoot growth of a wide range of species.

### Determination of Quality

Field emergence of soybeans correlated with laboratory tests.--Percent field emergence of soybean seeds was significantly correlated with standard germination, seedling growth, oxygen uptake, and respiratory quotients. However, correlations were higher when all lots were of the same variety than when lots from 4 different varieties were compared. Respiratory measurements at 6 hours after wetting were better than those at 2 or 4 hours for predicting emergence. Radioactivity from  $\text{Na}_2\text{S}^{35}\text{O}_4$  was incorporated into water soluble proteins of soybean and corn seeds in proportion to seed vigor. The reduced cost and increased safety of  $\text{S}^{35}$  as compared with  $\text{C}^{14}$  should enhance the potential usefulness of the biosynthetic test. Seeds of green-seeded lima bean varieties, bleached by sunlight during maturation, have a lower planting quality because of decreased germinability and growth. Bleached seeds lose their chlorophyll, and their ability to synthesize proteins and carbohydrates during germination becomes much reduced, leading to low vigor.

Germination equipment.--The automated two-way thermogradient plate developed by MQ proved to be an effective and reliable research instrument. Tests on rescuegrass seeds applied to the thermogradient plate produced information on optimum germination temperatures for dormant and nondormant seeds.

Light and seed germination.--Comparisons between tests made at Oregon State Seed Laboratory by official methods and tests at Beltsville by experimental methods indicated that low intensity fluorescent light (below 100 ft-c) should be specified in procedures for testing Kentucky bluegrass seeds and that daylight, incandescent, and high-intensity fluorescent light should be avoided. Prechilling procedures, currently used in official

testing, actually increased overall test durations. Non-prechilled seeds placed on substratum moistened with  $\text{KNO}_3$  and tested at 15-25°C alternating temperatures with unfiltered fluorescent light at 25° gave maximum germination in 14 days for cultivars Merion, Park, and Delta and in 21 days for Newport.

X-ray detection of seed damage.--The X-ray photographic technique was applied to seeds of plantation crops known for their poor storability under tropical conditions, viz., tea, coffee, rubber, cashew, pepper, and others. Defects such as empty seeds, rudimentary embryo or endosperm, and mechanical damage were easily detected. Following treatments with 20%  $\text{BaCl}_2$  for 2 to 4 hours after presoaking for 16 hours, most of the radiographic plates showed non-viable reactions, i.e., seeds were completely impregnated. Heavy infestation of rubber seeds with fungus could also be seen in the radiograms.

Seed extracts.--A technique for the collection of small samples from gas liquid chromatography by using capillary tubes at the end of the column was developed for analyzing various mixtures of aldehydes extracted from seeds of Hordeum spontaneum and Triticum dicoccoides. There was a decrease in concentration of certain aldehydes between 0-3 months storage, but not during the subsequent 3-7 months. Amounts of 9 mg p-hydroxy-benzaldehyde and 3 mg vanillin per Kg were extracted from the dispersal units (hulls) of Aegilops ovata. Another substance was also extracted from empty hulls of Aegilops ovata which apparently enhances light induced inhibition of lettuce seed germination and is active in minute quantities.

Other seed research.--The search for the existence of a phytin-dinucleotide phosphotransferase, which could conserve the energy present in phosphate bonds of phytin was continued. Experiments were made with synthesized radioactive phytin ( $\text{P}^{32}$  labelled) with ADP  $\text{C}^{14}$  and GDP $^{14}$ . All experiments have led to entirely negative results. No transferase reaction could be detected.

In mitochondrial preparations from germinating paddy and corn seedlings in vitro  $^{14}\text{C}$ -amino acids (phenylalanine, lysine) were incorporated into proteins. The process can be stimulated by the plant growth hormone, kinetin, and by synthetic messenger RNA's such as poly U or poly A. There is also some synergistic effect of these agents. Since mitochondria prepared at 10,000 g have been found more potent in  $\text{C}^{14}$ -incorporation, the experiments reported here have been carried out with that fraction.

## Protection from Harmful Microorganisms and Naturally Occurring Toxins

Seed pathological studies were continued.--Last year the production of a "halo" of brown pigment resulting from the interaction of certain metabolites produced by Helminthosporium oryzae and certain phenolic compounds was described. It was hoped to use this reaction as a simple diagnostic test for the detection of this serious pathogen of rice. Further study showed that a number of other seedbourne fungi of rice interfered with the test. Studies with pure cultures of Pyricularia oryzae, another serious pathogen of rice, have shown that halos of a characteristic color are produced in agar medium by interaction of fungal metabolites with guaiacol, sodium vanillate, orcinol or tyrosine at concentrations of 0.001 to 0.01 M. The weak parasite, Nigrospora oryzae, interferes with the test when guaiacol is used as the substrate, but not with the other compounds.

Seeds of 9 vegetable crops were inoculated with spores of Aspergillus amstelodami or A. flavus and stored at 75 or 85% relative humidity at 22-25°C for 30 days with non-inoculated seeds as controls. After 30 days these fungi had invaded only a few seeds of 5 kinds, but more seeds of the other four kinds. Fungus invasion did not cause a decline in germinability. One seed lot remained almost free of invasion but germinability declined appreciably. Seeds of 4 vegetables were inoculated with spores of A. flavus and stored for 12 weeks at 75 or 85% RH. The results of the 30-day and 12-week studies indicate that storage fungi may not be as important in the deterioration of stored vegetable seeds as in stored cereal grains. Apparently vegetable seeds stored in poor environments will decline markedly in germinability in the absence of storage fungi. Machine-threshed seeds of wheat stored for 16 weeks at 75, 85, or 90% RH suffered a faster and greater reduction in germinability than hand-threshed seeds stored under the same conditions.



## TOBACCO

## Determination of Quality

Tobacco enzymes.--Tobacco polyphenol oxidase was partially purified to a specific activity of nearly 5,000  $\mu\text{l O}_2/\text{mgP}/\text{min}$  compared to 50-100  $\mu\text{l O}_2/\text{mgP}/\text{min}$  in crude preparations. The enzyme from tobacco exhibits a much higher degree of substrate specificity than from other sources and has no hydroxylating activity. Gel filtration experiments indicate a molecular weight in excess of 200,000, probably because of aggregation. The enzyme can oxidize 3,4-dihydroxyphenylalanine, a compound previously reported not as suitable as a substrate. Its affinity for oxygen is low, indicating that under most conditions oxygen limits the enzyme's activity in vivo. The 50-100 fold increase in enzyme specific activity represents a higher degree of purification than previously reported.

Protection from Harmful Micro-organisms and  
Naturally Occurring Toxins

Toxic metabolites from tobacco fungi.--Toxic metabolites, including aflatoxins, were obtained by chloroform and chloroform-methanol extraction of the filtrates of 10 species of fungi, including Aspergillus clavatus, A. flavus, A. parasiticus, A. flavus-oryzae, A. versicolor, A. fumigatus, A. niger, Penicillium roseo-purpureum, P. frequentans, and Alternaria tenuis. These fungi represent the major fungi isolated from warehouse tobacco. The toxic metabolites were partially purified and their UV-absorption peak determined. The most toxic ones are undergoing intensive studies on their chemical and physical properties and their biological activities. Animal tissue culture methods were modified to test the mammalian toxicity of these fungal metabolites.

Smoke and smoke condensates from cigarettes made from moldy and non-moldy tobacco were applied to the respiratory surfaces of rodents. No differences in ciliary frequency, ciliary inhibition, mortality, and histological reactions were observed for the two types of tobacco. A study was done to determine the effect of substrate and inheritance on conidia size of Alternaria tenuis. Despite extremely variable conidia sizes, this characteristic is used to determine the proper binomial for the fungus that causes the brown-spot disease of tobacco. Substrate and inheritance did not affect spore size.

The numbers and kinds of fungi associated with 2 grades of tobacco sold in 2 markets within each of 5 tobacco belts were determined. Fungi isolated were similar to last year, mainly species of Alternaria, Aspergillus, and Penicillium. Slight differences in fungi populations were found on leaves harvested from different stalk positions. Alternaria tenuis was isolated more from upper leaves than from lower leaves; the reverse was true for Aspergillus spp. A cooperative study to determine if kojic acid, terreic acid, and terrein (mycotoxins) could be successfully silylated and subsequently resolved by gas chromatography was completed. The procedure was successfully tested on metabolic products of Aspergillus flavus grown on rice. The technique will be extended to tobacco.

Control of leaf fungi merits further testing. The number of viable fungus spores in a barn during flue curing was determined from air samples 6, 10, and 15 ft. above ground. After yellowing (the breakdown of chlorophyll) few viable fungi were in the air. Other data support the earlier conclusion that leaf fungi survive flue curing.

Four isolates of Aspergillus flavus were compared for their ability to produce aflatoxin. In a medium containing 5% yeast extract and 20% sucrose, the peak of toxin production was reached on the 4th day of incubation; whereas in the medium containing 2% yeast extract and 5% sucrose the peak was reached on the 6th day. Aflatoxin extracts from a culture medium previously treated with charcoal showed a somewhat altered UV absorption pattern and a slight difference in total fluorescence on TLC plates. These extracts had a higher than usual antibacterial activity. A slight reduction of antibacterial activity was detected with aflatoxin extracts from cultures autoclaved before solvent extraction. These findings provide a background for investigations in determining possible mechanisms which underlie differences in aflatoxin ratio and quantity among aflatoxin producing fungi.

#### Protection Against Insects

##### Biology, Ecology, Physiology, and Nutrition

Responses of cigarette beetle to temperature gradient.--Movement of late stage larvae of the cigarette beetle from hogsheads of tobacco under semi-controlled warehouse conditions occurred twice. The larvae responded to a temperature gradient in tobacco located near the hogshhead perimeter. All stages of the cigarette beetle remaining in the tobacco were killed by low temperatures. Temperatures near the center of tobacco hogsheads were below 40°F. for 90 days.

Tobacco moth mutant.--Developing testes of the larvae of the red-eyed mutant strain of the tobacco moth were not visible under ordinary light microscopic examination. In wild-type larvae, the testes appear as a dark brown spot on the dorsal side of the 5th abdominal segment of the last larval instar.

Cigarette beetle water balance and humidity relationship.--Third and fourth stage larvae of the cigarette beetle, when offered two levels of humidity, selected and remained at the lower level for 120 hours. However, with increase in age the response of 3rd stage larvae to different humidity levels decreased. At time of molt the larval response was negligible. Third and 4th stage larvae consistently selected the lower 3 humidity levels when offered a choice of humidities of 13, 33, 43, 53, 73, and 93% at 25° C. The addition of cornmeal did not alter the choice or selection. Third stage larvae continued to select the lower level of humidity when the differentiation between humidity levels was only 5% (55-60% and 60-65%). However, larval response was indefinite to a humidity differential of only 2 percent.

#### Biological and Physical Control

Pathogens of cigarette beetle.--The Bacillus disease of the cigarette beetle remains unidentified. Tests have shown mode of transmission to be mechanical.

Sex attractants of cigarette beetle.--Several active compounds from cigarette beetle females have been purified. A tentative structure of one of the compounds has been obtained. The compound, a C<sub>11</sub> alcohol, appears to be one of the most active components of the attractant. Synthesis work is in progress.

Collection of eggs and adult cigarette beetles.--Gravid cigarette beetles were induced to oviposit on non-food substances treated with ethanol extracts of food odors. Mean number of eggs deposited on filter paper per female was 30.5 and viability was 91.2%. Efficiency of electric grid traps with BL lamp versus the standard trap to capture the cigarette beetle was approximately 3X in tobacco storages and 10X in a tobacco factory.

#### Improved Insecticidal Control

Vacuum fumigation.--Manufactured cigars, boxed and packed in shipping cartons, were fumigated with ethylene oxide-carbon dioxide (10:90). Results from detector strips indicated that ethylene oxide easily penetrated the corrugated cardboard shipping cartons, but was restricted by each cellophane overwrap of cigar boxes and cigars. Only trace amounts of ethylene oxide permeated the 2 or 3 separate cellophane overwraps to reach the cigars.

Atmospheric fumigation.--Phosphine at 500 p.p.m. required exposures of near identical duration to kill all stages of the cigarette beetle as did concentrations of 100 p.p.m. Louvered warehouses were sealed satisfactorily for fumigation with phosphine when draped with tarps of 2-mil polyethylene. Overseas freight containers in sound condition were sufficiently gas-tight



for fumigation of tobacco cases with phosphine. The fumigant was evolved from aluminum phosphide pellets used at 165 per 1,000 cubic feet and exposure was for 72 hours at temperatures above 60° F., and for 96 hours when tobacco temperatures were lower than 60° F.

### Insect-Resistant Packaging

Packaging protectants.--The final breakdown of experimental insect-resistant 2-cubic-foot corrugated cardboard cases was made. During the second year of exposure, fewer cigarette beetles emerged from the hogsheads used as a source of infestation. There was a reduction in the number of new insect penetration holes in all liners. Liners made from 4 mil polyethylene gave more protection to the flue-cured tobacco than liners made from 1 mil films of polypropylene or polycarbonate. Some failures in the latter two plastics were due to breakage of the liners when the cases were prized with tobacco. Coatings of insecticide applied to the exterior surface of the cases were more effective than were interior coatings. Lindane was the most effective of the five insecticides (American Cyanamid 47300, Bay 77488, Dursban, lindane, and synergized pyrethrins) evaluated. However, tobacco prized in cases coated with lindane at 50 mg/ft<sup>2</sup> showed trace to very light damage caused by the cigarette beetle.



## VEGETABLES

## Quality Maintenance in Storage

Controlled atmosphere storage.--Many questions concerning the effect of controlled atmospheres on vegetable quality are being answered. As expected, we are finding that atmospheres differ in their effects on different commodities. Even the effect upon disease development differs considerably.

Lettuce.--The increased incidence of brown stain, a physiological disorder of lettuce, was correlated with increasing levels of carbon dioxide in the storage atmosphere. Approximately 16% of heads held in 2½% carbon dioxide, 38% in 5% carbon dioxide and 86% in 10% carbon dioxide developed the disorder. Injury was not always evident upon removal from the controlled atmosphere after 7 days at 38° F., but became more severe after 4 days at 50° in air. Significantly more heads developed brown stain when increased carbon dioxide levels were combined with 3% oxygen than when combined with normal oxygen. Decay, pink rib, and tipburn were not significantly influenced by the oxygen or carbon dioxide level. The general lettuce quality was no better in lots held in 3% oxygen than in lots held in air.

Onions.--Western-grown green onions in water-resistant cartons held at 32° F. kept much better in chambers supplied with a 1% oxygen and 5% carbon dioxide flowing atmosphere than in flowing air. The onions also kept better in controlled atmosphere than when stored with an ice covering in air. After 6, 8, and 10 weeks in controlled atmosphere storage, onions were judged to be excellent, fair to good, and fair, respectively. On removal from storage after 4 weeks in air at 32° F., green onions were rated poor but with minor trimming were rated good. Onions trimmed after storage retained good quality for 1 day at 70° or 3 days at 32° F.

Radishes.--Low oxygen storage atmospheres had little influence on root or top growth of radishes held at 36° F. Pithiness increased less in ¼ and ½% oxygen than at higher oxygen levels. Incidence of aerial mycelium from a field infection of downy mildew was 100% of radishes held in air and 36% of those in ¼% oxygen after 18 days. Incidence of new root growth for radishes stored at 50° F. ranged from 80% in air to 1% in ¼% oxygen. Radishes held in 2% or less oxygen were slightly crisper than those from 5% or 21% oxygen. Surface fungus growth and soft rot on roots stored in ½ and ¾% oxygen indicates that these concentrations were injurious at 50° F.

Sweetpotatoes.--Additional controlled atmosphere tests involving carbon dioxide and oxygen levels confirm previous findings that high carbon dioxide levels increase the pH which is nearly proportional to the level of carbon dioxide in the root.

Conventional storage.--Potatoes.--In order to gain a better understanding of storage losses and their causes, 14 commercial storages in the Red River Valley of North Dakota and Minnesota were monitored. Revealed were averages of 16.4% tuber damage at harvest; a 9° F. temperature variation; 89% storage relative humidity; 7.2% tuber moisture loss; and 26.4% storage decay loss.

Onions.--In tests at Beltsville, it was found that the storage life of green onions can be almost doubled by reducing temperature. Crated eastern grown green onions remained fresh and green at 40° F. for 1 week, but by 2 weeks, the tops were severely decayed and curled. However, when the storage temperature was reduced to 32°, the onions remained fresh and green for about 4 weeks. Following storage and consumer packaging, the onions remained salable for 1 day at 70° F., 3 to 5 days at 50°, or 10 to 14 days at 32°.

Desiccant foliage sprays were found to be of little or no value for drying the necks of onions. Tests in New York on preharvest applications of neodecanoic acid (Wiltz-65) or sulfuric acid showed that even though the onion necks were effectively dried, the bulb moisture level was increased. The increased bulb moisture made more artificial curing necessary.

#### Quality Maintenance in Transit

Celery.--Top-icing celery in rail shipments from California to the east coast improved quality. Top-iced celery shipped in mechanically refrigerated railcars with the thermostat set at 36° F. was more turgid than non top-iced celery with the thermostat set at 34° F. Railcar temperatures in California celery shipments to the east coast averaged slightly warmer and celery leaves were somewhat more yellow in the crosswise than in the lengthwise loads.

Lettuce.--Results of controlled atmosphere storage tests were not too beneficial for lettuce, although it did somewhat increase the yield of salable heads. In simulated domestic shipping (short term) tests, lettuce stored in controlled atmospheres with 1.5% carbon monoxide added had much whiter butts after 7 days at 38° F. than lettuce in other lots. However, a subsequent 4-day period at 50° F. in air eliminated the differences.

In simulated export shipping (long-term) tests, lettuce was stored 1 month at 36° or 41° F. in 21 or 3% oxygen with 0, 2, or 4% carbon dioxide, plus 3 days in air at 50° F. In some lots, the wrapper leaves were removed before storage. Carbon dioxide injured the lettuce in 3 out of 4 tests and low oxygen aggravated the carbon dioxide injury. High carbon dioxide with low oxygen effectively reduced decay but was no more effective than removal of wrapper leaves before storage in a normal atmosphere. High carbon dioxide inhibited pink rib development but low oxygen had the opposite effect. Yields of edible lettuce after 1 month storage were higher in controlled atmosphere than in air but only lettuce stored at 36° F. was salable regardless of storage atmosphere. The yield of salable lettuce was greatest in 3% oxygen with 2% carbon dioxide at 36° F.

Potatoes.--The chipping quality of Red River Valley potatoes was improved after shipment in bulk railcars. In general, all types of railcars tested maintained moderate temperatures during the transit period. The carbon dioxide content increased less in the 167,000 pound mechanical refrigerator car than in the companion RS car 2 days after loading. The oxygen content was reduced to 11.5% in the mechanical car and to 13.9% in the RS car during the same period. Changes in temperature in transit from that at which the potatoes were stored, whether an increase or decrease, changed the tuber quality as determined by chip color.

### Postharvest Physiology

Onions.--In a study related to onion storage tests conducted at Beltsville, the respiration rates for green onions expressed as milligrams of carbon dioxide produced per kilogram of onion per hour at specified temperatures were found to be: 78 to 178 at 70° F., 66 to 114 at 60°, 36 to 62 at 50°, 17 to 38 at 40°, and 10 to 27 at 32°.

Sweetpotatoes.--Research conducted at Raleigh revealed that carbon dioxide and pH were significantly increased and total acidity reduced in roots of 8 sweetpotato varieties after field applications of 1 and 1½ inches of water per day for 10 days. The roots dug at approximately weekly intervals during the fall showed only slight changes in pH, acidity, or carbon dioxide levels.

### Postharvest Disease Control

Cantaloups.--Research conducted at Fresno, California, to determine factors which predispose vegetables to postharvest rots has shown that cantaloups exposed directly to the sun during the last 9 to 17 days before harvest had significantly more surface fungus growth after 7 days at 42° F. plus 3 days at 68° F. than melons protected by white paint or shaded by plant leaves. It was found that the net heat gain of a white washed cantaloup was about 70% as high as that of a normal melon during rapid warming in the field. Respiration contributed from 4 to 15% to the net heat gain.

Other studies at Fresno to compare the effectiveness of heated fungicide suspensions with cold suspensions showed that cantaloups dipped in 1000 ppm benomyl at 135° F. for 30 seconds had the best general appearance and the least amount of stem scar and surface fungus growth of 8 different treatments tried. Thiabendazole and 2-aminobutane (carbonated form) were equally as good as benomyl for reduction of fungus growth. A 15-second exposure of cantaloups to 130° or 135° water containing 600 ppm captan was significantly more effective in controlling stem scar and surface fungus growth on cantaloups



than a standard commercial wax-sodium orthophenylphenate (SOPP) treatment. Manzate D and dimethyldithiocarbamate (SDMC) were equally as effective as captan.

Chinese chard (Bok-Choy).--Host inoculations, morphological and physiological studies using bacteria isolated from lesions and rotting tissue of Chinese chard from the Chicago market showed that Erwinia carotovora as well as Pseudomonas marginalis were the prominent causes of most market and transit decays affecting this commodity. The small, black superficial flecks noted on petioles of approximately 25% of the stalks increased in number when held in storage. However, this physiological disease was controlled when samples were held at 1° to 2° C.

Corn.--A fungus causing a red discoloration of sweet corn kernels in the Chicago market was isolated and pathogenicity of the as yet unidentified fungus was established.

Lettuce.--Rot predisposition studies conducted at Fresno revealed that lettuce heads exposed to high field temperatures had no more decay, pink rib, or russet spotting than uninjured lettuce after 1 week storage at 41° F.

Two physiological diseases of field origin and possibly caused by viruses are rusty brown discoloration (RBD) and internal rib necrosis (IRN). These diseases seriously reduced the market quality of many shipments that originated in the California desert growing areas during February and March 1970. The incidence of internal rib necrosis decreased from 64% at harvest to 100% 1 week later at storage temperatures of 32°, 36°, 41°, or 50°. Severity was greater at 50° than at 32°. The incidence of rusty brown discoloration increased from 8% at harvest to nearly 100% during 1 week at 32°, 36°, or 41° followed by 3 days at 50°. After continuous storage at 50°, incidence was 42%. Severity ratings at the above temperatures showed that the disorder was less severe at higher than at lower storage temperatures.

Neck rot and soft rot of onions in storage.--In storage rot control studies in New York, onion neck rot was found to range from 1% to 28% when inoculated onions were placed in simulated common storage for 3 months. The disease was most severe at the top of the pile of stored onions and least severe at the bottom. Bacterial soft rot ranged from 1.8 to 5% in the stored onions. Benomyl was more effective than thiabendazole, Lime Crest and tutane in controlling Botrytis neck rot during a 3-month storage period. None of the treatments controlled soft rot. Nine of 32 onion varieties were free of neck rot after 5 months in common storage. Only 2 varieties, Exporter Stokes and Elite Harris, were free of decay. Decay ranged from 2 to 19.3% in other varieties tested.

Prestorage applications of fungicides to potatoes.--Potatoes are traditionally stored with no attempt to control storage rots except by manipulation of the storage environment. Research is being conducted in Maine to determine the feasibility of reducing storage rots by applying preventative control



measures prior to placing potatoes in storage. In 1969-70, applications of chemicals before storage in small lots or in bulk bins controlled fusarium tuber rot (Fusarium oxysporium) in storage by 98-100%.

Effect of storage ventilation on tuber rot.--A bulk bin storage environment study directed toward determining what factors affect potato storage life showed 51% tuber rot in non forced-air ventilated storage compared to 21.5% in forced-air ventilated storage. The increased rot in non-ventilated storage indicates a possible relationship to carbon dioxide or oxygen buildup or depletion in storage which might adversely affect suberin and wound periderm formation during the curing period.

Effect of controlled atmosphere on rot development of tomatoes.--Fruit at various stages of ripeness inoculated with Erwinia carotovora and held 6 days at 55° F. kept significantly better in a controlled atmosphere with  $\frac{1}{4}$  or 3% oxygen and 5% carbon dioxide, and smaller on fruits stored in 3% oxygen and 5% carbon dioxide than on those stored in air. Storage in 5% oxygen and 5% carbon dioxide was no better than storage in air. Red fruit developed significantly less decay (42%) than pink fruit (78%) when both red and pink tomatoes were inoculated with soft rot bacteria and held 6 days at 55° F. Inoculated green and breaking fruit averaged 94% decay after this holding period. Inoculated but decay-free tomatoes held an additional week at 55° usually did not develop soft rot. In other tests, red and green tomatoes held in 3% oxygen and 5% carbon dioxide or in air for 8 days after inoculation developed less decay at 45° than at 55° or 65°. The low oxygen atmosphere was most effective in reducing decay at 55°.

Effect of mechanical harvesting.--The decreasing labor market and increasing labor costs are causing much concern to vegetable growers and is leading to more interest in mechanical harvesting for fresh market vegetables. Research is being conducted at the Orlando laboratory to determine the quality factors of tomatoes mechanically harvested for fresh market. Mature-green Florida tomatoes harvested with three different types of mechanical harvesters for the fresh market in the spring, fall, and winter had a higher incidence of damage than tomatoes harvested by hand picking. Subsequent losses from rots were ten times higher on damaged than on undamaged fruit. Little difference in decay occurred between mechanically or hand harvested tomatoes that were undamaged. It was found that more decay of undamaged harvested fruit resulted from packinghouse handling practices than from either the mechanical or hand picking operations. Research with other commodities such as carrots has shown a correlation between soft rot severity and populations of Erwinia spp. bacteria in dump tanks and wash waters.

Vegetable market losses.--Studies are being conducted in both the New York and Chicago markets to determine the extent and nature of vegetable market losses.

New York.--Wastage in central California iceberg lettuce marketed from May to October totaled 4.6% in warehouse samples, 4.8% in retail stores, and 6.0% in consumer samples held for 2 to 3 days at 38° to 40° F. Primary causes of losses were decay in warehouses, and bruising in retail stores and in consumer samples. Russet spotting was the most important nonparasitic disease.

California garlic with no waxy breakdown on arrival in the New York market had 1% of the cloves affected after 1 month at 34° F. There was no increase in breakdown during the following 5 months.

Chicago.--Losses on the Chicago market determined from back-room fresh packout (FP); retail shelf (RS); and consumer (C) were as follows: Celery - 3.63% FP, 0.63% RS, 3.47% C and total 7.73%; cucumbers - 2.43% FP, 4.38% RS, 2.66% C and total 9.47%; peppers - 2.95% FP, 2.80% RS, 5.94% C and total 11.69%; green beans - 2.75% FP, 1.56% RS, 8.76% C and total 13.07%; and tomatoes - 7.10% FP, 5.62% RS, 2.39% C and total 15.11%.

Several different strains of bacteria were isolated from California, Florida and Mexican tomatoes on the Chicago market which exhibited bacterial necrosis symptoms. The symptoms were reproduced when the different strains were inoculated into mature-green tomatoes. Results of the tests showed that each belong to the Pseudomonas and Aerobacter genera.

Fundamental research.--Related fundamental research was conducted at Chicago and Belle Mead, N. J., directed toward obtaining a better understanding of bacterial virulence, relation of enzymes to pathogenicity, spore longevity, and effect of tomato fruit phenolic acid on bacterial growth.

Avirulence in Erwinia carotovora was associated with (1) a greatly reduced production of all pectic and cellulolytic enzymes tested, (2) loss of phosphatidase activity, (3) altered colony morphology on triphenyl-tetrazolium chloride medium, (4) reduced growth on eosin-methylene blue, endo- and desoxycholate-lactose agar, (5) and an inability to liquefy gelatin or reduce and coagulate litmus milk. An induced reversion to virulence was associated with high levels of pectin, cellulolytic and phosphatidase activity only but not with the other characteristics of the wild-type strains. The enzymes, pectin esterase, polygalacturonase, pectin lyase, cellulase, and phosphatidase are collectively involved in virulence.

A differential localization of exo- and endopolygalacturonase was found in spores and spore matrix of Colletotrichum obiculare. Endopolygalacturonase was present in greater concentration in spore preparations, while exopolygalacturonase was concentrated in matrix preparations. Cellulase and an extremely active protease was also present in both spore and spore matrix preparations.

Results of morphological, physiological, and pathological tests of 120 isolates of Geotrichum candidum indicated that there were at least 6 distinct isolates. Longevity studies of 50 isolates showed that dried arthospore smears on glass slides remained viable for at least 6 months when held at 4° or 16° C. Studies using 12 isolates from human, animal and sewage sources indicated that some of these strains were identical to isolates found on fresh produce.

Antibiotic sensitivity tests of the phenolic acids reported present in tomato fruit showed that 0.5 mg of ferulic acid, p-coumaric acid, or chlorogenic acid in a filter paper disc inhibited growth of the bacterium, Erwinia carotovora, but 1.0 mg of caffeic acid per disc did not inhibit growth.

### Quality Evaluation

Determinations of lettuce head firmness.--Volume weight furnished the best method of separating lettuce heads into the 4 firmness categories--hard, firm, fairly firm, and soft. The difference in mean volume weight between the firm heads and the fairly firm heads was significant at the 0.05 level. All other differences were significant at the 0.01 level. Similar trends were obtained with X-ray exposure time and deformation at 10 pounds of force. However, differences in mean X-ray exposure time for the firm heads, the fairly firm heads, and the soft heads were not significant but the other differences were significant at the 0.01 level.

Measuring sweetpotato skin toughness.--The technique for measuring sweetpotato skin characteristics related to skin toughness (peeling force and failure force) was improved. Peeling force and failure force differed significantly among varieties and increased slightly during curing and storage. Peeling force appeared to increase more than failure force and appeared to be closely associated with retention of the skin.

Maturity of mature-green tomatoes.--The visual maturity score of cut mature-green tomatoes was correlated with a measurement of 2 wavelength pairs,  $\Delta OD$  510-580 nm and  $\Delta OD$  640-580 nm, made with a high energy multi-filter spectrophotometer. Correlation coefficients were: .89 for 3 varieties and 3 sizes combined; .86 for all sizes of C-17 variety; .80 for all sizes of Floradel variety; .77 for small fruit; .83 for medium fruit; and .84 for large fruit. None of the fruit had been previously separated for presence of hollow or partially hollow locules which pass extraneous light and cause invalid measurements. A solution of ethyl alcohol (0.97 specific gravity) proved effective for separating hollow locule fruit from normal fruit.

Tomatoes sorted with the 4-filter multiple wavelength difference meter (LTDM) were analyzed for chlorophyll, lutein, lycopene and b-carotene by cooperators at the University of Rhode Island. Correlations between LTDM values and chemical analysis, respectively for the 2 wavelength pairs were: chlorophyll a .55 and .68; chlorophyll b .55 and .85; lutein -.12 and -.15; carotene -.82 and -.97; and lycopene -.91 and -.85.



## WOOL AND MOHAIR

## Determination of Quality

Felting instrument.--An instrument for testing felting power of loose wool samples was developed. It showed that felting power was not highly associated with the handle or softness and is associated even less with fiber diameter. The sectioning instrument used for sample preparation for Coulter Counter measurement of fiber diameter was modified to yield more uniform samples and less blade wear. Wool samples representing 4 wool producing areas of the country, Wyoming, Texas, California, and the Midwest, are being evaluated for resiliency and fiber diameter.

## Protection Against Insects

## Nontoxic Mothproofing

Preliminary evaluation of protectants.--Penick SBP-1382, a synthetic pyrethroid-type insecticide, was the most promising of 28 compounds evaluated as mothproofers in the past year. This compound is of interest because of its low mammalian toxicity and its resistance to removal by cleansing of woolen fabrics.

Improvement of mothproofing treatments.--Gardona applied to woolen cloth in practical home-type applications that resulted in initial deposits of 0.14 to 0.38% by weight still satisfactorily protected the cloth against black carpet beetle larval feeding after the treatments had aged 2 years.

Gardona was applied to woolen cloth from a laboratory padding machine. Estimated deposits and the actual residues by analyses were very close, indicating that little selective pickup of chemical occurred.

A deposit of 0.50% Gardona by weight applied to rubberized hair as an emulsion spray protected it against black carpet beetle larval feeding.



## INSECT CONTROL IN MARKETING CHANNELS--CROSS COMMODITIES

## Biology, Ecology, Physiology, and Nutrition

Mitochondrial metabolism in the Indian-meal moth.--Oxygen consumption per unit live weight decreases during larval growth, reaches a minimum in the midpupal period, and subsequently increases in the adult. Alterations in total mitochondrial protein content and in specific activity of mitochondrial enzymes account for these changes. Male moths attain a respiratory rate that is twice as high as the females. Permeability characteristics of larval mitochondria suggest carbohydrates are catabolized via malate and pyruvate, while proteins are catabolized via glutamate. Fats are oxidized very slowly. However, retention of dietary fats only accounts for a portion of the lipids accumulated by larvae. The de novo synthesis of fats originates with mitochondrial citrate which is translocated to the cytoplasm of the cell; succinate may facilitate this translocation through the mitochondrial membrane. Citrate-cleavage enzyme forms acetyl coenzyme A for fatty acid synthesis. The activities of the alpha-glycerophosphate-dihydroxyacetone phosphate shuttle and the malate-oxalacetate shuttle decrease at the onset of lipid synthesis, thus trapping reducing equivalents in the cytoplasm. This action augments the diversion of intermediates through reactions catalyzed by malic enzyme and glucose-6-phosphate dehydrogenase which in turn convert the reducing equivalents to the form required for lipid synthesis. Studies on larval midgut ultrastructure revealed the two classical cell types, goblet cells and columnar cells, plus a third cell type that progressively accumulated large secretory droplets as the insect grew.

Photoperiod studies with the Indian-meal moth.--Spermatogenesis in male Plodia interpunctella is greatly affected by light conditions. Under light-dark cycles, large numbers of normal spermatozoa are produced in the male and transferred during mating. As a result, egg production in the female is high. In contrast, males reared under continuous light do not have sufficient numbers of normal spermatozoa to transfer at mating and as a result the females mated to these males are not stimulated to lay. Examinations by light and electron microscopy of males reared in continuous light showed that the majority of spermatozoa produced by these males was smaller in diameter than of those produced by males reared in light-dark cycles. Data from these studies may provide an explanation to the occurrence of spermatozoan dimorphism in Lepidoptera.

Humidity and insect behavior.--The variation in the response of adult O. surinamensis with the position of the humidity alternatives on the relative humidity (RH) scale was determined by examining their response to the following RH alternatives: 0-40, 10-50, 20-60, 40-80, 50-90, 55-95, and 60-100%. Both sexes responded hygronegatively when the alternatives were situated in the upper portion of the RH range, but the male response was stronger. In the lower portion of the RH range, both sexes were indifferent or showed only weak responses except at 10-50% RH where they showed a strong hygropositive response.

The interaction of the humidity response of adult male O. surinamensis with their light and tactile responses was examined. Interactions occurred with all the alternatives used (60-100, 20-60, and 0-40% RH).

Scanning electron micrographs were made of all the antennal segments of adult male O. surinamensis. These show that basiconic sensilla occur only on the three club segments. This, along with the results of antennectomy experiments, suggests that these sensilla mediate the humidity response. Additional scanning electron micrographs were made to determine the distribution of the sensilla on the club segments.

Bionomics of Trogoderma.--The number of insects examined for disease thus far exceeds 6,000. The most common pathogen observed infecting Trogoderma is the eugregarine, Mattesia trogodermae. A coccidian parasite, Adelina spp., has been found causing mortality in a very few population samples. Cross-infection experiments performed with the coccidian from T. parabile verified our previous identification of the parasite from its taxonomic description as being Adelina tribolii.

More than 2,700 field collections were examined. Collections were taken from feed mills in various climate zones of California so correlations could be made between natural infestations found in food packets exposed to infestation and populations found in industrial plants where sanitation is minimal.

Bionomics of stored products in export commodities, carriers, and facilities.--Studies are proceeding in port warehouses, railcars delivering commodities to the ports, and commodities carried by the railcars. The insect fauna resident in port warehouses seems to show a seasonal variation, both in abundance and makeup. Cultural practices used by the ports also appear to influence the abundance and makeup of insect infestations. The most common insects found infesting ports in order of abundance are cigarette beetles, almond moths, Indian-meal moths, and red flour beetles. Each of the four ports under investigation represents a different ecological situation with respect to physical plant, commodities handled, and applied control programs. Attempts are being made to correlate these factors and others with the frequency of occurrence and relative abundance of stored-product insects.

The most common insects causing the rejection of flour cargoes being delivered to ports by rail are, in order of frequency, red flour beetles, hairy fungus beetles, lesser grain borers, and various dermestids. Attempts are being made to correlate these infestations with insect populations resident in farinaceous debris that gets caught behind the wood liners or in cracks, crevices, and other places in boxcars.

Nutrition of the almond moth.--The levels of protein and carbohydrate for optimal growth, development, and reproduction for the almond moth are not the same. Fastest development occurred at a protein/carbohydrate ratio of 25/65 and 5/85. Maximum survival occurred at 45/45 level. The largest number of eggs were produced from females developing on the 25/65 diet.

Four diets, the nucleic acid, the amino acid, the sitosterol, and the nucleic acid-B vitamin, were tested against the control. The nucleic acid diet produced a noticeably faster growth rate. The amino acid diet gave a slower development. Although some of the larvae reared on the nucleic acid-B vitamin diet developed faster than those from the control, most developed slower. The sitosterol diet had the highest survival rate followed by the nucleic acid diet. Survival was low for the amino acid diet and particularly the nucleic acid-B vitamin diet. Females from the nucleic acid diet produced the largest number of eggs.

Larval growth retardation and/or high mortality were caused when thiamin, riboflavin, pyridoxine, Ca pantothenate, folic acid, biotin, and nicotinic acid were individually omitted from the diet.

Use of food by stored-product insects.--In recent studies, the uric acid method was used to compare the utilization of diets consisting of cracked wheat, whole wheat flour (germed and degermed) plus 5% brewer's yeast, and wheat germ alone. Wheat germ promotes a greater and more rapid weight gain than the other diets largely because the wheat germ which is digested is used for growth twice as efficiently as the digested portion of any of the other diets. Larvae provided with cracked wheat digest more of what they eat than do larvae provided with finely ground flour made from the same batch of wheat. Thus, the difference in digestibility cannot be due to a difference in nutrient composition. The results indicate that larvae provided with large particles may be able to feed selectively upon certain portions of the kernel.

Micro-organisms from alimentary canals of beetles.--Larval, pupal, and pre-emergence adults of S. granarius were found to be bacteriologically sterile within kernels of wheat. Bacteria from emerged adults included Escherichia intermedia, Proteus rettgeri, P. vulgaris, Bacillus subtilis, Serratia marcescens, Streptococcus spp., Micrococcus spp., and members of the Klebsiella - Aerobacter group.



The number of Salmonella typhimurium and Escherichia coli varies with time in its environment within A. diaperinus under laboratory conditions. Adult A. diaperinus were collected locally from poultry brooder houses and examined for E. coli and Salmonella spp. The Salmonella recovered were S. heidelberg, S. worthington, S. saint paul, S. typhimurium, and S. chester. Twenty-six of 48 E. coli serotypes recovered are known pathogens for man or animals.

Amino acids and vitamins in physiology of insects.--The results of amino acid analyses reveal the presence of some nonessential amino acids in addition to essential ones. The nonessential amino acids though not required in the diet for growth may be used in other biochemical processes.

The qualitative analysis of vitamin requirements showed Panthotenic acid, Nicotinic acid, Choline chloride, and Riboflavin as the most essential vitamins, and others such as Pyridoxin, Folic acid, and Biotin as of less importance. The studies on the quantitative requirements show that a very small quantity of vitamins, Nicotinic acid, Panthothenic acid, Riboflavin, and Choline chloride are required for the survival and development of this pest.

Morphology and chemistry of odoriferous glands.--The odoriferous glands of adult lesser mealworms, Alphitobius diaperinus, are identical in males and females as are the secretions of these glands in the two sexes.

The glands consist of 2 main structures; the glandular secreting cells and a large bifurcated reservoir. The forked reservoir appears as 2 elliptical bodies with a ventromedial connection. The basal region is continuous with an opening to the outside and the reservoir is essentially an infolding of the conjunctiva. It is most closely associated with the 5th sternum with one side of the opening forming a continuous membrane connecting with the 6th sternum. The structure of the wall is similar to the intima lining the tracheae.

Gas chromatographic analyses of a chloroform solution of the crude secretion revealed 6 peaks, with 2 compounds in relatively large amounts. In one analysis an additional early-eluting peak was present. Use of infrared, TLC, and mass spectrometry indicated that the 2 major components were 2-methyl-1,4-benzoquinone and 2-ethyl-1,4-benzoquinone present in a ratio of 1:5. A 3rd compound was apparently a 1,4-benzoquinone derivative; the retention time of the peak found in the one experiment was the same as 1,4-benzoquinone.



## Biological and Physical Control

Controlled atmospheres.--Five virgin male and five virgin female confused flour beetle adults were confined on media in containers in which the oxygen was maintained constantly at about 21% and the amount of carbon dioxide was varied. After 60 days at 22% carbon dioxide no progeny were found; at 18% an average of 15 insects (including P generation) was found; at 15% an average of 156 insects was found; and at 10.6, 5.3, and 0.03% an average of 964 to 1,104 insects was present.

Wheat infested with maize weevil adults for 1 week was held for 1, 2, 3, 4, or 5 weeks and then exposed for 1, 2, 3, or 4 days to various concentrations of atmospheric gases. Concentrations of 100% nitrogen or nitrogen with a small amount of oxygen were not as effective in reducing emergency as were ternary mixtures containing 46% or more carbon dioxide. The only mixture effective after the infestation was 3, 4, or 5 weeks old was a ternary mixture containing 60% carbon dioxide.

Wave energy.--Preliminary tests were conducted to study the combined effects of microwave and gamma irradiation on the immature stages of Angoumois grain moths, rice weevils, and lesser grain borers within wheat kernels. The mortality and sterility data are being analyzed for synergistic, additive, or antagonistic characteristics.

Tests were also conducted to determine if heating of infested Soft Red Winter wheat with microwave energy, followed by exposure to a standard fumigant,  $\text{CCl}_4$ , affects the mortality of immature rice weevils within the wheat kernels when compared with mortality caused by fumigation alone. Data from these tests are being analyzed.

Gamma radiation.--Inshell and shelled peanuts were infested with Plodia interpunctella, Tribolium castaneum, or Oryzaephilus surinamensis and then treated with 10, 20, or 40 krad of gamma radiation. Progeny produced by the beetles was greatly reduced or eliminated by the 10-krad treatment, and higher levels were completely effective. Plodia were not eliminated by the 10-krad treatment, and a few survived the 20-krad treatment. Control was complete with 40 krad.

One-half of a lot of artificially infested and noninfested white wheat flour in 50-lb. bags was irradiated at 30-50 krad. After 6 months' storage insects were present in the artificially infested, nontreated flour; none were present in the irradiated flour.

Four species of insects have failed to develop resistance to radiation through subjecting each generation to substerilizing radiation through 6-10 generations. The midgut was shown to be a site of serious injury in

irradiated P. interpunctella and Tenebrio molitor. Possible use of the sterile-male technique in controlling P. interpunctella has been shown.

Insect sound detection.--Field evaluation of an aural monitor for detecting hidden infestation was carried out. The monitor was also evaluated as a research tool by using laboratory-infested cultures of S. oryzae as the test insect. These cultures were aurally monitored for response to gamma radiation, temperature extremes, and various gaseous atmospheres. Electronic integration of the monitor output permits low-speed recording of in-kernel insect activity. Tests using a single post-pupal insect showed continuous activity with no diurnal variations and no periods of dormancy. Recordings of a near-homogeneous culture containing approximately 100 insects clearly showed larval feeding, pupal quiescence, followed by increasing adult activity leading up to emergence.

Biophysical studies.--An iris-like structure, previously undescribed in the insect eye, has been found in Tribolium castaneum. Functionally blind strains of the red flour beetle have been found to possess normal eye morphology.

Effects of sensory stimulation (light) upon development of the reproductive system of male Plodia have been studied with special attention given to relationships between the neuroendocrine system and the gonads and other components of the reproductive tract. No direct neuroendocrine innervation of the testes has yet been found, and it has been tentatively concluded that the effects of sensory stimulation upon gonadal development and spermatogenesis are probably humorally mediated.

Grain chilling.--Grain-chilling studies were initiated in wheat stored in an insulated metal bin. Only one test was run before winter due to difficulties encountered with the grain-chilling unit. Chilling began in the afternoon when the outside temperature was 75.4° F., and concluded the next morning after 17.5 hours of operation. Outside temperature dropped to 61.7° F., during the night the chiller was operated. The initial average temperature of the grain was 71.2° F. (range 69.1° F. to 75.0° F.). This was reduced to an average of 55.1° F. (range 49.0° F. to 66.0° F.) during the period the chiller was in operation. The relative humidity of the intergranular air was reduced from an average of 37.8% to an average of 35.7% during the chilling period. The cost per bushel to chill the wheat was 0.19¢. During the next 30 days there was a period of warm days and cool nights with five cold nights in the 30° F. range. Outside temperatures ranged from 30.5° F. to 77.8° F. (average 59.3° F.), while the temperature of the grain rose an average of 5.2° F. Relative humidity of the intergranular air during this period was 23.5% to 45.5%. This grain bin was monitored

constantly for 4 months. Outside temperatures averaged 52.1° F. (range 19.0° F. to 77.8° F.), while the grain temperature has averaged 54.7° F. (range 38.1° F. to 64.3° F.).

Pathogens.--A microbial insecticide incorporating a granulosis virus of the Indian-meal moth was formulated. The product, a wettable powder, was produced with the cooperation of the IMC Corporation, utilizing virus material cultured in our laboratory. Tests are in progress to determine the virulence of the product, and its efficacy as a protectant against Indian-meal moth infestation of stored grain and tree nuts.

Electron microscope studies indicate that a granulosis virus of the almond moth will develop aberrantly when transmitted to the Indian-meal moth; however, the aberrant virus develops normally when transmitted back to its natural host.

Pathogenic parasites were frequently observed in samples of dead and moribund stored-product insects received for diagnosis. About 80% of over 400 larvae of the Indian-meal moth examined from Georgia were infected with a granulosis virus. Navel orangeworms collected in California were observed infected with Rickettsiella, Nosema, Plistophora, Bacillus thuringiensis, and Aspergillus. The virulence of several commercial products containing B. thuringiensis was assayed in preparation for testing their efficacy as a protectant against the navel orangeworm on almonds.

Chemical constituents of foods to control insects.--Two chemical components, saponin and genistin, were isolated from Davis variety soybeans. Purified genistin constituted about 0.042% of the soybean. It was nontoxic to rice weevils, and did not affect the development of cowpea weevils. Saponin was purified by solvent recrystallization and preparative thin-layer chromatographic separation to obtain a portion toxic to rice weevils. This portion constituted about 0.07% of the soybean, and contained about three chemical components. Laboratory study revealed that a dosage of 600 p.p.m. of saponin inert dust on wheat was protective against rice weevils. The calcium salt of soybean saponin was also toxic to rice weevils.

Fresh citrus peel oils from lime, grapefruit, and lemon used as 1% surface treatments on black-eyed peas were effective in preventing damage by cowpea weevils up to 4, 8, and 32 weeks, respectively, in laboratory studies. Lemon peel oil was fractionated by various chromatographic methods. A toxic portion to cowpea weevils was isolated by either liquid column chromatographic or thin-layer chromatographic fractionations (about 4% and 5.5%, respectively). This toxic portion contained about 6 chemical components. Two of these components were nontoxic and were identified by thin-layer chromatography to be 5,7-dimethoxycoumarin and methyl anthranilate.



Effects of sounds on insects.--The receptors for airborne sounds in the rice weevil, Sitophilus oryzae, are believed to be the Johnston's Organs in the second antennal segment. Although the weevils respond to physical manipulation of body hairs by means of contact with bristles, air currents other than at high levels of flow do not generally elicit responses when the Johnston's Organs are inactivated.

Fusion of the apical segment of each antenna onto the snout with paraffin, leaving all antennal segments, except the last, free and uninjured, abolishes responses to airborne sounds. In this case, the Johnston's Organs are fixed but normal. As long as the antennae are thus fastened, there are no responses to sound or to air currents. The responses reappear when the paraffin seal is broken and the antennae are set free.

Sex attractant of Indian-meal moth.--Large numbers of males of two noctuid species were attracted to female Plodia interpunctella. Caged virgin females of P. interpunctella stationed in the field in the summer attracted males of Spodoptera exigua and Heliophana mitis. No males of these species were captured in nonbaited cages. These findings establish the existence of cross-attraction in lepidopterous species of different superfamilies and are significant in devising means to sample or control lepidopterous pests.

Although results of field studies indicate cross-attraction between P. interpunctella and C. cautella, virgin males of each species released and trapped in the laboratory exhibit a definite preference or attraction to females of their respective species. Studies are in progress to determine if this specificity is caused by structural differences in the primary sex pheromone, the presence of modifying pheromones in females, or other possible factors.

Field studies on wind direction and attraction of male P. interpunctella to caged females show conclusively that males approach caged virgin females from downwind. These results support the hypothesis that the volatile sex pheromone is the primary mode of attraction of P. interpunctella males to females.

Neuroendocrine system of Sitophilus. Ultrastructural studies were initiated on the neuroendocrine system of the adult female granary weevil including the lateral and medial neurosecretory cells of the brain, the corpora cardiaca, and corpora allata. Results from electron microscopy support the earlier findings from light microscopy but in addition reveal an apparent cycle of the lateral neurosecretory cells. The perikaryon of some lateral cells has been found to be insulated by glia from adjacent nerve cells. How extensive this insulation is on the cell body and its axon, whether tight junctions exist between the glial and neuronal membrane, and whether this insulation is a feature common to all lateral cells are still under investigation.



Parasites and predators of Indian-meal moth.--Work is continuing in inoculating a standard-size colony of Indian-meal moth larvae with varying numbers of parasites, and in observing effect of parasitism after a 4-week interval. These experiments are directed toward determining the concentration of parasites relative to host numbers that yield the lowest number of surviving Plodia. It is also hoped that the experiments will explain the anomalous pattern noted earlier--that higher concentrations of parasites kill fewer insects than lower concentrations.

A sampling system is now in use that permits the larvae to migrate at will from the center of a circular container for a given time. Migrating larvae are isolated into compartments by a metal grid which is pushed down through the medium. Compartments are evacuated separately; larvae from each are counted and reared. Variables under consideration are: (1) Rate of migration, (2) sex, (3) age of larvae, and (4) distance covered. Arrangements have been made to record data on IBM cards, and analysis of results will be computerized.

Quinones and Tenebrionid population regulation.--Egg viability of Latheticus oryzae was nearly equivalent in p-benzoquinone and natural conditioning to that of the control series (83.6%). In methyl p-benzoquinone, it was slightly lower (78.64%). The mean duration of the egg stage was 6.40 days in the control series. The mean was not significantly different in naturally-, artificially-, p-benzoquinone-, or methyl p-benzoquinone-conditioned media. Net fecundity was significantly reduced by naturally conditioned medium compared to control.

The mean duration of the larval period in p-benzoquinone and in methyl p-benzoquinone conditioning was similar to the control. The only significant change, an increase, was noted with naturally-conditioned medium.

Masking sex attractants.--Since the compound trans-3-cis-5-tetradecadienoic acid has been shown to elicit strong responses in male Attagenus megatoma, a number of synthetic compounds which are closely related were tested for both masking and attractant properties. The compounds were tested on insects to determine how structural modifications affected the behavior of the test species. Results showed that activity varied with the position of double bonds, chain length, additional functional groups, and carboxyl placement. Synthesis of compounds related to the sex attractant of A. megatoma is continuing in an effort to delineate the absolute structural requirements of this natural product.

Physiological control.--Research in Israel has demonstrated that high levels of a common, relatively-insoluble vitamin can cause temporary sterility in insects. Complete sterility did not occur until 48 hours after feeding on excess of biotin, a B-vitamin. Using C<sup>14</sup> labeled biotin, it was

found that the biotin levels in the insect eggs and sterility decreased in successive egg batches after feeding of excessive quantities of biotin was stopped. Eggs containing surplus biotin displayed normal activity of acid phosphatase and analogous enzymes, but revealed markedly suppressed proteolytic activity.

Mating habits of dermestid beetles.--The sex pheromone of Attagenus elongatulus females has been extracted with ether. Preliminary purification steps suggest it is a free fatty acid. Purification is continuing.

Only 50% of Trogoderma inclusum females mate more than once when placed in 8 oz. jars containing food and one male. In 5 dram vials almost 100% of the females mate more than once. Females previously mated to a sterile male produce only about 40% as many offspring as those mated first to normal males. A ratio of 16 sterile males to each normal male will reduce to less than 10% the females producing offspring.

Materials with juvenile hormone activity.--Indian-meal moth, red flour beetle, and cigarette beetle larvae and/or pupae were treated topically with compounds having juvenile hormone activity or the compounds were administered in the diet. With the exception of the red flour beetle pupae, topical applications were not too effective. Candidate compounds were checked for their ability to prevent pupation when administered orally throughout the last larval instar. The most effective compounds (50 p.p.m. in the diet) against the Indian-meal moth were Ayerst AY-22,342-2 and Stauffer R-20458. Feeding the moth larvae on untreated diet just prior to pupation negated the effects of hormone fed earlier. The Ayerst compound was also the most effective against the beetles with some last instar red flour beetle larvae having as many as 7 extra moults. Cigarette beetles were more resistant to the effects of the added hormones than were the red flour beetles. Treating kernels of wheat with hormones did not affect the development of internal feeding insects.

Chemical components of plants resistant to stored-product insects.--Analytical investigations were primarily on Coker 67 shelled corn.

Lipids were fractionated into their main classes, and their constituent fatty acids were quantitatively and qualitatively determined.

The phospholipid fraction contained a constituent that was characterized by the presence of fatty acids, carbohydrates, and a basic constituent. This component contained bound glucosamine, mannose, galactose, and an unidentified carbohydrate. A coupled basic constituent contained nitrogen and could be oxidized to form an aldehydic-reactive material. This compound may be identical to phytosphingosine which has one of the constituents present in phytoglycolipid, as unique sphingolipid present in corn.

## Mode of Insecticide Action and Development of Resistance

Resistance to insecticides.--Indian-meal moth larvae from Georgia peanuts, Iowa corn, and South Carolina rye showed very high resistance to malathion but low resistance to synergized pyrethrins and to Bay 77488. Crosses of white-eyed and malathion-resistant almond moths indicated that resistance is dominant and in a different linkage group.

DDT resistance in khapra beetle.--Phospholipase A, responsible for hydrolysis of phospholipids, particularly lecithin, was shown to be present. The enzyme activity vs. time and activity vs. enzyme concentrations gave a linear relationship. The enzyme activity appeared to be only present in the female pupa and adult.

The penetration and distribution of DDT in the larvae and adults were studied using  $^{14}\text{C}$ -DDT. It is possible one of the causes for larval resistance to DDT may be a faster rate of excretion than in the adult.

## Improved Insecticidal Control

Preliminary evaluation.--Of 67 new insecticides tested, 25 were promising for followup tests. LD values were determined for six compounds against four insect species. Of 56 compounds tested, seven showed greater repellency than did the standard. Toxicities differed with site of application of malathion on red flour beetles. A 4-liter jar was adapted for testing vapor toxicity of liquids.

Practical control problems.--Insecticide sprays on external surfaces of plywood overpacks used in military shipments of foods to Vietnam did not prevent insect infestation of improperly sealed or damaged bags of flour stored 6 months. In a 1-year storage of flour in overpacks there was no rodent damage and loss of the IR treatment on the bags was reduced.

At 160 aluminum phosphide pellets per 1,000 ft.<sup>3</sup>, a 72-hour fumigation of flour in plywood overpacks covered with 4-mil polyethylene films was effective against five species. Inefficient aeration of methyl bromide from bags of vacuum-fumigated flour resulted in a rapid buildup of bromide residues.

Micronized insecticidal dusts were generally more effective as space treatments than aerosols against stored-product insects in airplanes and in truck vans.



## Insect-Resistant Packaging

Paper-protectant bags.--In tests to simulate storage of empty multiwall bags, saran-coated kraft, ethylene vinyl acetate wax-coated kraft, and greaseproof paper eliminated or greatly reduced migration of piperonyl butoxide into the inner plies. A uniaxially oriented, cross-laminated polyethylene film reduced insecticide migration and a spounbonded olefin film did not. Paper coatings of butoxy polypropylene reduced but did not prevent insect penetration into treated bags. Three synthetic pyrethroid package protectants have been as effective as synergized pyrethrins in uncompleted tests. A uniaxially oriented, laminated olefin film was more resistant than conventional polyethylene film to insect penetration. During a 12-month storage test with 25-lb. bags containing three commodities, the most effective insecticide barriers were some saran coatings over styrene butadiene and greaseproof paper, while glassine, polyvinyl acetate-coated kraft, saran over polyethylene, and light saran coatings over styrene butadiene were not good barriers. There was generally more migration into CSM (cornmeal, soy flour, dry milk) (6% fat) than into cornmeal (3% fat) or flour (1% fat). A large-scale test is being started to evaluate insecticide barrier plies and the insect resistance of heat-sealed polyethylene liners in 50-lb. insect-resistant treated multiwall kraft bags.

Cotton-protectant bags.--It was shown that insects can oviposit through the weave of cotton fabric, explaining why insect-resistant treated, loosely laminated cotton bags were infested during 6 months' storage. Newly designed bags, constructed to reduce cost, increase effectiveness, and minimize residues, will be evaluated in large-scale storage tests with commodities having high (6%) to low (1%) fat contents. Included are bags with saran-coated kraft barriers and bags having woven sides and unplasticized polyvinyl chloride film liners.

## Fate and Effect of Residues

Analyses made.--A total of 7,085 samples were analyzed for insecticide residues in the past year. These samples originated within the Branch from experimental treatments to prevent or control insects in various stored products.

## Toxicology

Action of fumigants on animals.--Fumigation experiments with carbon tetrachloride were conducted by gravity penetration and recirculation. Only by the second method were homogeneous residues obtained. Preliminary



experiments with forced airing did not result in efficient desorption. Samples of fumigated wheat still contained up to 10 p.p.m. after a year of storage. Bread baked contained only a small residue (less than 0.5 p.p.m.).

Feeding trials with mash fumigated at different levels of CTC were carried out on growing male and female rats and lambs to test effects on growth rate and sexual development.

Lambs were much more susceptible to the presence of CTC in the mash. Restricted feed intake, leading to cessation of growth, occurred when there was a level of 100 p.p.m. At a level of 35 p.p.m., growth was proportional to the intake. Only when 20 p.p.m. was present in the mash were food consumption and growth similar to those of the controls. Blood transaminase activity and liver fat levels were normal in all treated lambs, indicating symptoms of CTC poisoning.

In contrast to previous findings with bulls, mature ram spermiogenesis was not affected by ethylene dibromide.

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## CRIS WORK UNITS

## Market Quality Research Division

Number	Title	Location
FC-2	:Laboratory methods for estimating seed vigor	:Beltsville, Md.
FC-3	:Verification of varietal designations of crop : seed	:Beltsville, Md. :
FC-4	:Development of methods for routine testing of : seed for pathogenic fungi	:Beltsville, Md. :
FC-5	:Study of environmental conditions on seed : germination	:Beltsville, Md. :
FC-7	:Relation of fungi to quality of seeds, grains, : and their products	:Beltsville, Md. :
FC-9A	:Predicting the storage life of seeds	:State College, Miss.
FC-10PL*	:X-ray techniques for evaluating seed quality	:New Delhi, India
FC-11PL*	:Isolation and structure of germination : inhibitors in seeds	:Rehovoth, Israel :
FC-12PL	:Biological basis of physiological phenomena in : seed germination	:Jerusalem, Israel :
FC-14PL*	:Maintenance of seed germination in storage	:Reutlingen, Germany
FC-15PL*	:Factors affecting physiological maturity and : dormancy of grass seeds	:Munster, Germany :
FC-18	:Measuring fungal contamination and metabolites : in grain	:Beltsville, Md. :
FC-26	:Measuring protein content of grain sorghums and : other feed grains	:Beltsville, Md. :
FC-27	:Evaluation of the quality of gamma-irradiated : cereal grains	:Beltsville, Md. :
FC-28	:Relation of lipids to grain soundness and : quality	:Beltsville, Md. :
FC-29*	:Methods of detecting extent of stinkbug damage : in soybeans	:Beltsville, Md. :
FC-31C*	:Automatic determination of weight per bushel of : grain	:Kansas City, Mo. :
FC-32C	:Development of a method to determine sound : grain	:Manhattan, Kansas :
FC-33C	:Optical properties of grains and foreign : materials associated with grains	:Minneapolis, Minn. :
FC-34C	:Develop a method and device to isolate and : concentrate the germ of grains	:Manhattan, Kansas :
FC-35C*	:Development of a grain moisture instrument	:Columbus, Ohio
FC-38	:Sanitary quality and wholesomeness of "further : processed" poultry products	:Beltsville, Md. :
FC-39	:Control of <u>Salmonella</u> on fresh market poultry	:Beltsville, Md.
FC-40	:Methods for detecting salmonellae in poultry : and egg products	:Beltsville, Md. :
FC-41A	:Reducing <u>Salmonella</u> contamination of broiler : chicken carcasses during processing	:Newark, Delaware :



FC-43A*	: <u>Erysipelothrix insidiosa</u> infection in market : turkeys	:Stillwater, Okla. :
FC-46	:Commercial drying, handling and storage of : peanuts	:Raleigh, N.C. :
FC-47*	:Objective measurements of market quality in : peanuts	:Raleigh, N.C. :
FC-48*	:Methods and equipment for evaluating the : quality of peanuts	:Raleigh, N.C. :
FC-49	:Rapid detection of molds and/or aflatoxin in : peanuts	:Raleigh, N.C. :
FC-54PL*	:Physiological and biochemical factors in the : production of aflatoxin by <u>Aspergillus flavus</u>	:Delhi, India :
FC-55	:Meat flavor as a palatability standard	:Beltsville, Md.
FC-56	:Objective criteria of meat quality	:Beltsville, Md.
FC-58C	:Identification of meat slaughtered by approved : methods	:College Station, Tex. :
FC-62C	:Fineness and softness as quality factors of : wool	:Laramie, Wyoming :
FC-65	:Effects of previous history of cotton lint on : market quality	:Clemson, S.C. :
FC-68	:Cotton fiber testing instruments and : techniques	:Clemson, S.C. :
FC-70	:Methodology studies for development of : improved cotton spinning performance tests	:Clemson, S.C. :
FC-71A	:Measuring factors affecting spinning performance : and product quality of cotton	:Clemson, S.C. :
FC-72	:Apparatus for blending a sample of cotton lint	:Clemson, S.C.
FC-75	:Maintaining quality of rough rice during off- : farm handling, conditioning and storage	:College Station, Tex. :
FC-77	:Aflatoxin production in cottonseed	:College Station, Tex.
FC-78	:Basic factors in development of mycotoxins : in peanuts and rice	:College Station, Tex. :
FC-82A	:Relationship of fungi on corn to aflatoxin : production and clinical diseases of : livestock	:Lafayette, Indiana :
FC-83	:Effects of improved handling, conditioning and : storage on market quality of peanuts	:Dawson, Georgia :
FC-84	:Objective measurements of market quality in : raw peanuts	:Dawson, Georgia :
FC-85	:Rapid detection of molds and/or fungal : metabolites in peanuts	:Dawson, Georgia :
FC-86*	:Chlorinated insecticide residues in animal : products and feeds	:Beltsville, Md. :
FC-88	:Recovery of bacteria from heat injury	:Beltsville, Md.
FC-89*	:Moisture distribution in butter	:Beltsville, Md.
FC-91	:Objective measurement of quality and physical : characteristics of milled rice	:College Station, Tex. :
FC-96PL	:The origin and characterization of mustiness : in wheat	:Poznan, Poland :
FC-97PL	:Survey of growth of <u>Aspergillus flavus</u> and : aflatoxins in cottonseed	:Hyderabad, India :

FC-98PL	:Microflora and mycotoxins in stored sorghum, : rice and groundnuts	:Mysore, India :
FC-99PL	:Indicator organisms in dairy and food products	:Rajasthan, India
FC-101	:Measurement of drafting force and its : variability under cotton processing : operations	:Clemson, S.C. : :
FC-102	:Inhibition of <u>Salmonella</u> and other bacteria : in milk and dairy products by essential oils	:Beltsville, Md. :
FC-102A	:Post mortem changes in quality and functional : properties of bovine muscle proteins	:Stillwater, Okla. :
FC-103C*	:Determination of objectionable odors of grains	:Chicago, Illinois
FC-104C	:Detection of hidden-insect infestation in grain	:Kansas City, Mo.
FC-106C*	:Investigations on the carcinogenic and other : toxic metabolites produced by tobacco fungal : flora	:Lexington, Kentucky : :
FC-110A	:Microflora of flue-cured tobacco and their : effect on quality	:Raleigh, N.C. :
FC-113	:Development of a standard grain breakage test	:Manhattan, Kansas
FC-115	:Electrophoretic patterns of soluble proteins : from bacteria	:Beltsville, Md. :
FC-116	:Variation in yeast and its effect on the : experimental baking test	:Beltsville, Md. :
FC-117	:Design and development of an automatic grain : sample divider	:Manhattan, Kansas :
FC-118	:Identification of vegetable proteins added to : meat products	:Beltsville, Md. :
FC-119	:Changes in quality indicators as corn and : wheat are stored under various conditions	:Beltsville, Md. :
FC-120	:Mechanisms of fungus deterioration affecting : market quality of peanuts	:Dawson, Georgia :
FC-121	:Effect of cotton properties and residues on : fiber quality	:Clemson, S.C. :
FC-122	:Improving microbiological condition of : eviscerated broilers	:Athens, Georgia :
FC-123C	:Development of an automatic rice sizing device	:Baton Rouge, La.
FC-124	:Chemical and biological control of micro- : organisms in stored grains	:Manhattan, Kansas :
FC-125	:Accurate and rapid objective tests for : evaluating quality of bread crumb grain and : crumb color	:Beltsville, Md. : :
FC-126	:Microflora of tobacco and their effect on : quality	:Raleigh, N.C. :
FC-128	:Effect of cottonseed storage on oil quality	:Beltsville, Md.
FC-129	:Equipment to determine hidden-insect : infestation in grain	:College Station, Tex. :
FC-130C	:The fate of polyphenols in tobacco during air : curing	:Lexington, Kentucky :
FC-131PL	:Assay methods, toxicology, biosynthesis, : incidence, production and control of : aflatoxins in grains	:Poznan, Poland : :

FC-132	:Improved packing, shipping and storage methods : for unfrozen poultry	:Beltsville, Md. :
FC-133	:Biochemical characteristics of fungal : metabolites	:Dawson, Georgia :
FC-134A	:Development of a method to determine general : appearance of grains	:Fargo, N.D. :
FC-135PL	:Occurrence of adipose, connective and fibrillar : tissues in muscles of slaughter animals	:Lublin, Poland :
FC-136	:Biochemical changes associated with seed : deterioration	:Beltsville, Md. :
FC-138*	:Methods for identifying and determining the : extent of weevil damage in dried pea	:Beltsville, Md. :
FC-139	:Biochemical characterization of microbial : deterioration of meat	:Beltsville, Md. :
FC-140A	:Yield grade of lambs as related to quality : loss during storage and transit	:Beltsville, Md. :
FC-141C	:Composition and quality factors of imitation : milks	:Ithaca, New York :
FC-143A	:Development of a laboratory device for : determining milling yield of rice	:College Station, Tex. :
FC-144	:Effect of commercial storage practices on : molds and aflatoxins in cottonseed	:Beltsville, Md. :
FC-145C	:Biological significance of aflatoxins in : tobacco and their decomposition products	:Lexington, Kentucky :
FC-146PL	:Effect of growth promoters and inhibitors on : the synthesis of proteins in germinating : seeds	:Calcutta, India :
FC-147C	:Determination of nitrogen by reduction with : hydrogen	:Baton Rouge, La. :
FC-148C	:Determination of nitrogen by oxidative : combustion	:Chicago, Illinois :
FC-149C	:Thermalanalytical studies of grain moisture	:Columbus, Ohio
FC-150	:Development of methods and techniques for : evaluation of market quality of oilseeds : and oilseed products	:Beltsville, Md. :
FC-151**	:Study of nonaqueous volatile matter evolved : during oven moisture assay in grains	:Beltsville, Md. :
FC-152**	:Improved method and device for determining : kernel hardness of grains	:Manhattan, Kansas :
FC-153**	:Improving design and performance of mechanical : sampling devices	:Manhattan, Kansas :
FC-154**	:Effect of physical/chemical properties of grain : on deviations of electrical moisture meter : results	:Beltsville, Md. :
FC-155**	:Development of mycotoxins during marketing : of sorghum grain in the Southwest	:College Station, - :
FC-156**	:Development of laboratory tests to determine : the most feasible procedure to remove : aflatoxin from specific lots of shelled : peanuts	:Raleigh, N.C. : :

FC-158A\*\*:The influence of eight distinctly different body :Madison, Wisconsin  
: types of beef cattle on growth, body composition:  
: and meat quality :

FC-159C\*\*:Development of a Flat Bed Fiber Sampler :Knoxville, Tenn.

FC-160C\*\*:Modification of Cotton Fiber Strength Analyzer :Dallas, Tex.

FC-161C\*\*:Modification of Cotton Fiber Length Analyzer :Dallas, Tex.

FC-162A\*\*:Boneless meat yield of six major sow carcass cuts:Madison, Wisconsin  
: and trimmed pork loins :

FC-163C\*\*:Mycotoxins in relationship to tobacco and :Lexington, Kentucky  
: health :

FC-164C\*\*:Development of a production prototype of an :Kansas City, Mo.  
: automatic test weight device :

FC-168C\*\*:Development of a device for weighing individual :Brookings, S.D.  
: kernels of grains :

FC-169A\*\*:Salmonella and fecal contamination of meat :College Station, Tex.  
: during livestock slaughtering :

FC-170C\*\*:Using microwave energy for determining moisture :Kingsville, Tex.  
: of grains :

FC-171C\*\*:Measuring mass of cotton fiber test specimen :Knoxville, Tenn.  
: in determining cotton fiber strength :

FC-172C\*\*:Influence of grass and of bark on spinning :Lubbock, Tex.  
: performance of cotton :

FC-173PL :Studies on the metabolism of Aspergillus :Delhi, India  
\*\* : flavus with reference to the production of :  
: aflatoxins :

FC-174C\*\*:Development of an objective method for classi- :Chicago, Illinois  
: fying odors of grains :



HC-1	: Improved methods for storage of apples	: Beltsville, Md.
HC-2	: Treatments for control of postharvest rots and : functional disorders in apples and pears	: Beltsville, Md.
HC-3	: Improved methods for storage of stone fruits	: Beltsville, Md.
HC-4	: Treatments for control of postharvest rots of : stone fruits	: Beltsville, Md.
HC-5	: Product requirements for storage and packaging : of selected root crops and leafy vegetables	: Beltsville, Md.
HC-6	: Modified atmosphere effects on mature-green : tomatoes	: Beltsville, Md.
HC-8	: Improved handling and storage of cut flowers, : bulbs, and plants	: Beltsville, Md.
HC-9	: Reduced atmospheric pressure as affecting stor- : age life of tomatoes, bananas and berries	: Beltsville, Md.
HC-10*	: Role of enzymes of microorganisms in the death : of vegetable tissues	: Beltsville, Md.
HC-11	: Objective methods for measuring maturity and : quality of apples	: Beltsville, Md.
HC-13	: Objective measurement of maturity in mature- : green tomatoes	: Beltsville, Md.
HC-14	: Objective measurement of color of potato chips	: Beltsville, Md.
HC-16	: Treatments for control of postharvest decay of : onions	: Belle Mead, N.J.
HC-17	: Role of fungal proteolytic enzymes in the : death of fruit and vegetable tissues	: Belle Mead, N.J.
HC-18	: Identification and causes of market diseases : of fruits and vegetables	: Belle Mead, N.J.
HC-19	: Extent and nature of market losses of fruits : and vegetables	: Belle Mead, N.J.
HC-21*	: Identification and incidence of decay in : specialty fruits and vegetables from Puerto : Rico	: Chicago, Illinois
HC-23	: Identification and causes of market diseases : of fruits and vegetables	: Chicago, Illinois
HC-24*	: Extent and nature of market losses of fruits : and vegetables	: Chicago, Illinois
HC-25	: Treatments and environments for handling, : storage and transportation of potatoes and : precut seed	: E. Grand Forks, Minn.
HC-26	: Bruise injury and bruise injury susceptibility : of potatoes	: E. Grand Forks, Minn.
HC-27	: Protecting quality of fresh strawberries : during air or surface transportation	: Fresno, California
HC-28	: Heat pasteurization and fungicides for con- : trol of decay of strawberries, figs and : grapes	: Fresno, California
HC-29	: Effects of weather and field diseases on : postharvest quality of lettuce and melons	: Fresno, California
HC-30	: Effects of controlled atmospheres and heat on : the activity of decay organisms	: Fresno, California
HC-31	: Controlled atmosphere effects on cauliflower, : radish, asparagus and broccoli	: Fresno, California

HC-32*	:Protecting quality of lettuce during rail and : truck transport	: :Fresno, California
HC-34	:Improved handling and storage of cut flowers and : ornamental plants	: :Fresno, California
HC-35*	:Improved methods for storage of Texas grapefruit	:Weslaco, Texas
HC-37*	:Extending the market life of Texas grapefruit : in foreign markets	: :Weslaco, Texas
HC-38	:Improved methods for storage of subtropical : fruits	: :Miami, Florida
HC-40*	:Factors influencing the effectiveness of : chlorine for decay reduction in vegetables	: :Orlando, Florida
HC-41	:Improved methods for storage of Florida citrus : fruits	: :Orlando, Florida
HC-42	:Control of postharvest rots in Florida citrus : fruits	: :Orlando, Florida
HC-43*	:Objective methods for measuring maturity and : quality of citrus fruits	: :Orlando, Florida
HC-44*	:Components of citrus rind tissue which affect : germination or growth of decay organisms	: :Orlando, Florida
HC-45	:Improved methods for storage of California : oranges and lemons	: :Pomona, California
HC-46	:Modified atmosphere effects on the growth of : citrus decay organisms	: :Pomona, California
HC-47	:Citrus volatiles as a measure of market quality : during storage	: :Pomona, California
HC-48	:Extending the market life of California citrus : fruits in foreign markets	: :Pomona, California
HC-49	:Methods for handling and storage of precut seed : potatoes	: :Presque Isle, Me.
HC-50	:Improved prestorage and storage treatments for : reduction of wastage in potatoes	: :Presque Isle, Me.
HC-51	:Composition of blueberries as related to inci- : dence of postharvest decay	: :Raleigh, N.C.
HC-52	:Improved methods for handling and storing : sweetpotatoes	: :Raleigh, N.C.
HC-53	:Objective methods for measuring maturity and : quality of apples	: :Wenatchee, Wash.
HC-54*	:Treatments for control of postharvest rots and : functional disorders of apples and pears	: :Wenatchee, Wash.
HC-55	:Relationship between preharvest environment & : postharvest quality in apples and pears	: :Wenatchee, Wash.
HC-56*	:Improved methods for storage of stone fruits	:Wenatchee, Wash.
HC-57A	:Relation between preharvest environment and : postharvest quality in apples and pears	:Oregon State Univ. :Corvallis, Oregon
HC-58A*	:Indices of maturity and storage requirements : for new pear varieties	:Univ. of Maryland :College Park, Md.
HC-60A	:Modified atmosphere effects on celery, sweet : corn and tomatoes	:Univ. of California :Davis, California
HC-61*	:Development of bulk bin sampling methods for : processing tomatoes	: :Beltsville, Md.
HC-62*	:Development of instrument for removal of : undercolor tomatoes from inspection sample	: :Beltsville, Md.

HC-63PL	:Metabolic changes during storage and ripening of : mangos	:Univ. of Baroda :Baroda, India
HC-65PL*	:Metabolic changes during maturation and ripening : of avocados	: :Rehovot, Israel
HC-67PL*	:Antimicrobial action of biphenyl and derivatives : on citrus spoilage organisms	: :Munich, Germany
HC-68	:Storage and marketing of <u>Actinidia chinensis</u> : (Chinese gooseberry)	: :Fresno, California
HC-69	:Improved precooling methods for grapes and : strawberries	: :Fresno, California
HC-70	:Maintenance of cut flower color after harvest	:Bradenton, Florida
HC-71	:Improving the keeping quality of Florida-grown : cut flowers	: :Bradenton, Florida
HC-72C	:Toxicity and carcinogenicity of diphenylamine : to mice	:Albany Medical College :Albany, New York
HC-73A	:Market quality of citrus fruits as related to : mechanical harvesting	:Univ. of Florida :Lake Alfred, Florida
HC-75	:Thermotherapy and chemotherapy for control of : postharvest decay of stone fruits	: :Fresno, California
HC-76**	:Objective methods for measuring firmness of head : lettuce	: :Beltsville, Md.
HC-77**	:Identification of the virulence enzymes in : phytopathogenic soft rot bacteria and fungi	: :Chicago, Illinois
HC-78**	:Improved handling, cooling and shipping prac- : tices for lettuce and celery	: :Fresno, California
HC-79**	:Evaluation of instrument measurement of delayed : light emission (DLE) and chlorophyll content : of raw tomato juice	: :Beltsville, Md.
HC-80**	:Quality and losses of exported U.S. agricul- : tural commodities in Europe	: :Rotterdam, Netherlands
HC-81**	:In-store prepack and consumer losses of selected : fresh fruits and vegetables in the Chicago : market	: :Chicago, Illinois
HC-82**	:Development of improved methods of degreening : citrus fruits	: :Orlando, Florida
HC-83**	:The effects of mechanical harvesting and packing- : house systems on vegetable damage and post- : harvest decay	: :Orlando, Florida
HC-84PL **	:Biosynthesis and mode of action of ethylene in : fruits	: :Beit Dagan, Israel
HC-85PL **	:Postharvest behavior of apples and pears :	:Ljubljana, Yugoslavia :
HC-86**	:Control of scald on apples and pears	:Wenatchee, Wash.
HC-87**	:Chemical and non-chemical control of postharvest : rots of western apples and pears	: :Wenatchee, Wash.
HC-89A**	:Fungi and possible mycotoxins associated with : pecans in storage	:Univ. of Georgia :Athens, Georgia
HC-90A**	:Quality maintenance of mechanically harvested : horticultural crops	:Clemson University :Clemson, S.C.



SP-1C*	:Isolation, identification, and synthesis of sex attractants for <u>Trogoderma inclusum</u> and T. <u>glabrum</u> .	:Stanford Res. Inst. :Menlo Park, Calif. :
SP-2PL	:Lipids and their metabolism in relation to DDT resistance by <u>Trogoderma granarium</u> .	:Univ. of Delhi :Delhi, India
SP-5A*	:Non-insecticidal control of stored-product insects by induced changes in microbial symbionts.	:Univ. of Wis. :Madison, Wis.
SP-6A	:Residual insect-control treatments for food-processing facilities and storage areas.	:Univ. of Wis. :Madison, Wis.
SP-7	:Preventing insect damage to dairy products in marketing channels.	:Madison, Wis. :
SP-15PL	:Ecological studies and fumigation of <u>Trogoderma granarium</u> .	:Punjab Agric. Univ. :Ludhiana, India
SP-16	:Preventing insect damage to tobacco and tobacco products in marketing channels.	:Richmond, Va. :
SP-18G	:Comparative life histories and bionomics of <u>Trogoderma</u> species.	:Univ. of Calif. :Riverside, Calif.
SP-20G*	:Effects of sorghum varieties on development of two species of rice weevil.	:Calif. State Coll. :Los Angeles, Calif.
SP-21G*	:Location, structure and functions of sound receptors in stored-product insects.	:Univ. of Okla. :Norman, Okla.
SP-22A*	:Biology and behavior including sex attractant of the Angoumois grain moth, <u>Sitotroga cerealella</u> .	:Kans. State Univ. :Manhattan, Kans.
SP-23A*	:Nutrition of the almond moth, <u>Cadra cautella</u> .	:Gainesville, Fla.
SP-24A*	:Utilization of food by certain stored-product insects.	:Univ. of Ill. :Urbana, Ill.
SP-25A	:Insect-bulgar relationships affected by environmental factors including fumigation.	:Kans. State Univ. :Manhattan, Kans.
SP-26A*	:Microorganisms from alimentary canals of beetles that attack stored products.	:Univ. of Minn. :St. Paul, Minn.
SP-27A	:Water regulation physiology and stress in stored-product insects.	:Kans. State Univ. :Manhattan, Kans.
SP-28A	:Association of insects to dangerous microorganisms in stored grains.	:Kans. State Univ. :Manhattan, Kans.
SP-30A*	:Effects of gamma radiation on reproduction and physiological processes of <u>Acarus siro</u> .	:Univ. of Ga. :Athens, Ga.
SP-31A*	:Sex attractant of female Indian-meal moth, <u>Plodia interpunctella</u> .	:Univ. of Ga. :Athens, Ga.
SP-32A	:Endocrinology of reproduction in <u>Sitophilus</u> sp.	:Clemson, S. C.
SP-33A	:Effects of parasites and predators on population dynamics of Indian-meal moth.	:Clemson Univ. :Clemson, S. C.
SP-34A	:Fate of malathion residues on grain sorghums.	:Manhattan, Kans.
SP-36A	:Role of quinones in regulating populations of confused flour beetle, <u>Tribolium confusum</u> .	:Cornell Univ. :Ithaca, N. Y.
SP-37A	:Morphological and taxonomic characters of immature stages of <u>Carpophilus</u> beetles.	:Calif. Dept. of Agric. :Sacramento, Calif.
SP-38PL	:Varietal resistance of wheat to rice weevil and lesser grain borer.	:Ind. Agric. Inst. :New Delhi, India
SP-39PL*	:Physiology of the khapra beetle <u>Trogoderma granarium</u> with emphasis on fat metabolism.	:Univ. of Baroda :Baroda, India
SP-40PL	:Use of antimetabolites for the control of certain stored-product insects.	:Hebrew Univ. of :Jerusalem



SP-41PL	:Role of active substances produced by the khapra beetle in mixed populations of stored insects.	:Hebrew Univ. :Jerusalem, Israel
SP-42PL*	:Constituents of rice, wheat and dairy products that attract insects.	:Tokyo Univ. :Tokyo, Japan
SP-43PL*	:Effect of pesticides on keeping quality and nutritive value of harvested plant commodities.	:Univ. of Helsinki :Helsinki, Finland
SP-44PL	:Ecology of mites attacking dried fruits and herbs.	:Warsaw Agric. Univ. :Warsaw, Poland
SP-45PL	:Effect of inert dusts, insect pathogens, temperature and humidity on stored-product insects.	:Univ. of Zagreb :Zagreb, Yugoslavia
SP-46	:Preventing insect damage to dried fruits in marketing channels.	:Fresno, Calif. :
SP-47	:Preventing insect damage to tree-nuts in marketing channels.	:Fresno, Calif. :
SP-48	:Preventing insect damage to rice and rice products in marketing channels.	:Beaumont, Tex. :
SP-49	:Preventing insect damage to wheat and wheat products in marketing channels.	:Manhattan, Kans. :
SP-50	:Preventing insect damage in the mid-west to corn and corn products in marketing channels.	:Manhattan, Kans. :
SP-51	:Preventing insect damage to grain sorghums in marketing channels.	:Manhattan, Kans. :
SP-52	:Preventing insect damage in the South to corn and corn products in marketing channels.	:Tifton, Ga. :
SP-53	:Preventing insect damage to farmers stock peanuts in marketing channels.	:Tifton, Ga. :
SP-54PL	:Role of amino acids and vitamins in the physiology of certain stored-product insects.	:Univ. of Rajasthan :Rajasthan, India
SP-55	:Evaluation of chemicals to protect wool, hair and feathers from insects.	:Savannah, Ga. :
SP-56	:Controlled atmospheres for protecting stored products against insect damage.	:Savannah, Ga. :
SP-57	:Detecting and controlling stored-product insects with sound, light and near-visual light.	:Savannah, Ga.
SP-58	:Gamma radiation effects on insects and development of treatments for grains and packaged foods.	:Savannah, Ga.
SP-59	:Develop insect-resistant packages using paper, paperboard, plastics and other materials.	:Savannah, Ga. :
SP-60	:Develop insect-resistant cotton bags.	:Savannah, Ga.
SP-61	:Evaluation and development of insecticides to control insects in foods and feeds in marketing channels.	:Savannah, Ga. :
SP-62	:Insecticide residues from experimental treatments to prevent or control insects in stored products.	:Savannah, Ga.
SP-63	:Detection of hidden insect infestations in grain.	:Savannah, Ga.
SP-64	:Morphology and function of stored-product insect sensory receptors.	:Savannah, Ga.
SP-65	:Mitochondrial metabolism during development of Indian-meal moth.	:Savannah, Ga.
SP-66	:Effect of photoperiod and temperature on Indian-meal moth.	:Savannah, Ga. :
SP-67	:Effect of humidity on behavior of <u>Oryzaephilus surinamensis</u> and <u>O. mercator</u> .	:Savannah, Ga.

SP-68PL	:Stored grain insect pests and their control in :Uttar Pradesh, India.	:Uttar Prad. Univ. :Nainital, India
SP-69PL	:Effect of legume seed components on digestive and :endocrine system of certain insects, chicks and :rats.	:Inst. Biol. Res. :Belgrade, :Yugoslavia
SP-70PL	:Mechanism of action of halogenated hydrocarbon :fumigants on animals.	:Hebrew Univ. :Rehovot, Israel
SP-71A	:Isolation and characterization of insect phero- :mones of the cigarette beetle, <u>Lasioderma</u> :serricorne (F).	:Univ. of Wis. :Madison, Wis.
SP-72A*	:Water balance and the humidity relationships of :the cigarette beetle, <u>Lasioderma serricorne</u> .	:Ohio Agric. Center :Wooster, Ohio
SP-73C*	:Synthesis of megatomoic acid.	:Menlo Park, Calif.
SP-75A	:Investigations of masking of sex attractants of :stored-product insects.	:Univ. of Ga. :Athens, Ga.
SP-76	:Temperature for protecting stored products :against insect damage.	:Savannah, Ga. :
SP-77	:Chemical constituents of natural foods for con- :trolling stored-product insects.	:Savannah, Ga. :
SP-78	:Microbial control of insects attacking stored :products in marketing channels.	:Fresno, Calif. :
SP-79PL	:Application of gamma rays for the control of some :major stored-grain pests.	:Min. Food & Agric. :West-Pakistan
SP-80PL	:Control of khapra beetle ( <u>Trogoderma granarium</u> ).	:West-Pakistan
SP-81	:Basic research on biology, ecology, physiology, :and nutrition of stored-product insects.	:Gainesville, Fla. :
SP-82A	:Determination of chemical components of plants :resistant to stored-product insects.	:Univ. of Ga. :Athens, Ga.
SP-83	:Morphology and chemistry of the odiferous glands :of the lesser mealworm.	:Univ, Md. :College Park, Md.
SP-84A	:Degradation products and metabolites of BAY 77488 :on wheat.	:Kans. State Univ. :Manhattan, Kans.
SP-85A	:Control of stored-product insects with anti- :microbial agents and food preservatives.	:Univ. of Wis. :Madison, Wis.
SP-86**	:Reducing losses caused by insects in harvested :soybeans throughout the marketing channels.	:Manhattan, Kans. :
SP-88A**	:Basic research on pheromones, hormones, and :enzyme systems in stored-product insects.	:Univ. of Fla. :Gainesville, Fla.
SP-89A**	:Sex attractants of selected stored-product :lepidopterous pests.	:Univ. of Ga. :Athens, Ga.
SP-90A**	:Effect of environmental factors on food consump- :tion and utilization by stored-grain insects.	:Univ. of Ill. :Urbana, Ill.
SP-91A**	:Attractant studies with <u>Trogoderma glabrum</u> .	:Syracuse, N. Y.
SP-92PL**	:Dosage compensation and its genetic implications :on the pest of stored grains, <u>Sitophilus oryzae</u> :(L.).	:Univ. of Calcutta :Calcutta, India :

\* Initiated during reporting year.

\*\* Terminated during reporting year.



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